ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 63. No. 9. 220 Broadway, New York, March 3, 1910.

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Economical Freight Transference at Railway Terminals and Shipping Docks.

By H. McL. HARDING.*

It has not been definitely realized in the past that the problem of efficient transportation under modern conditions is largely a terminal problem. The loss of time at terminals and intermediate handling points has been notorious, but that the costs arising at these points are extremely high has not been known. The great expense arising from conditions such as pictured in the view on this page is rarely given due thought.

In particular the cost of handling terminal package freight, whether railway or water-borne, has not been clearly appreciated until within a short period. It was known only in a general way that this cost was great; that it was becoming excessive; that any congestion increased the expense; that rehandling must be avoided, and that freight houses and transfer stations were becoming inadequate and congested, and that the rate of annual increase was large. Such figures as were given were often combined with other station expenses, so that it was difficult to determine what proportion should be charged to freight handling.

CANAL-BOATS AT A TERMINAL IN NEW YORK HARBOR.

(Only the crudest methods of handling freight are available. Wharf space is so limited that boats must wait days for opportunity to unload.)

In reply to inquiries as to the cost of handling transfer freight, an official wrote that he had inquired, and that it was 4 cts. per ton. Later it was learned by him that it was 24 cts. per ton. He had evidently telephoned and the "four" was all he had heard, and he wrote this in his letter. In another case an operating superintendent of a water terminal boasted that he knew to the fraction of a mill what it cost to handle his terminal freight, and had it down in his note-book. He was advised by another superintendent to burn that book, if he were wise.

When it was noticed by executives that the terminal charges were becoming the great items of expense of freight transportation, and an investigation was made, the cry was raised by the freight agents, "What is the saving of one or two cents a ton in comparison to diminished efficiency and the loss of freight business, due to dissatisfied shippers and consignees?" Thus the terminal expenses came to be put in the same category with death and taxes, things which could not be changed or avoided. Even the engineers were not supposed to be trained in the intricacies of freight handling, and if they were too inquisitive the freight agent could always be relied upon to prevent interference with existing conditions.

Often, in an elaborate collection of figures giving the number of tons handled per day, the morning and afternoon deliveries and receipts, the dray and hand truck loads, certain vital figures are omitted, so that the cost per ton handled could not for a certainty be determined. There are now, however, figures available, not only from a few localities, but embracing many places and under varying conditions of operation. The figures as herein given refer to the cost of handling package or miscellaneous cargo freight, which on railways is termed L. C. L. freight, and on barges or steamers general cargo freight.

Mr. M. L. Byers, Chief Engineer of Maintenance of Way, Missouri Pacific Ry., in his important work, "The Economics of Railway Operation," estimates the cost of handling freight by manual labor, including car switching, as 41 cts. per ton. This refers to house freight. Mr. Byers states that in a freight house 300 ft. long and 35 ft. wide the average trucking is about 120 ft. If this can be reduced to 50 ft. it represents a saving of 3 to 5 cts. per ton. On this basis to truck 1,000 ft., even with no delays for loading or unloading or weighing, is demonstrated to be exceedingly expensive. Mr. Byers also states that any rehandling always means large proportional increase of expense. Congestion usually means a rehandling of the freight.

The new Toledo terminal, a combined outbound, inbound and transfer station of the Lake Shore & Michigan Southern Ry., is (in accordance with the local conditions) one of the best in the United States for economical manual freight handling. According to the Transactions of the American Railway Engineering & Maintenance-of-Way Association, the average cost at this station is 35 cts. per ton.

Major George W. Stephens, Chairman of Montreal Harbor Commission, in a recent interview, said it cost before 1909 on 400,000 tons of harbor terminal freight 40 cts. per ton, or $160,000, with manual handling. During the last season, due to direct transference, this has been reduced to $80,000. They are now installing modern freight-handling machinery to secure the full reduction.

According to the Report of the Chicago Harbor Commission, March, 1909, the cost of loading and unloading steamer freight in Chicago is 59 cts more than at Milwaukee. This is due to Milwaukee's excellent terminal facilities for handling package freight.

The manager of one of the Atlantic Coast Transportation lines states that it costs in New York 35 cts. per ton to land and place upon the piers, provided there is no congestion. Much congestion may increase the cost to 50 cts. Additional space is difficult to secure and is expensive, therefore congestion cannot be avoided if manual labor is to be continued. To place this freight upon drays costs 20 cts. per ton additional. To unload this same class of freight from the same steamers on piers at southern ports cost 50 cts. per ton. Though the cost for labor per hour is not so much, it is about one-third less efficient.

At another New York pier on the North River, inbound transfer-float freight costs 44 cts. per ton. At a large transfer station of a New England railroad the cost, including all supervision, is 31 cts. per ton.

At a transfer station where nearly 2,000 tons are handled daily, the cost is said to be approximately 23 cts. per ton; the men receive about $2.25 per day for 9½ hrs. work. Where about 1,700 tons was the daily tonnage at another transfer station, the cost is 24 cts., the men receiving 17½ cts. per hr.

At a transfer station where the trucker received 15.8 cts. per hr., the cost for trucking alone was 23.5 cts. per ton.

The cost of handling freight per ton at a station of the Illinois Central Ry., in Chicago, is as follows: inbound 40 cts., outbound 35 cts., team freight less than 4 cts. From data from other stations the cost for team freight per ton is given at 8.3 cts. per ton. The difference is due to what is included under cost.

In one case, the house handled freight is said to cost 49 cts. per ton. In this case there is no transfer or team freight. It will be noticed that the average cost varies according to the

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Fig. 2. Interior of a Miscellaneous Cargo Pier.

Fig. 4. A Ship at Dock in Galveston, Texas.
(Hand trucks and an inclined board do all the unloading and transferring.)

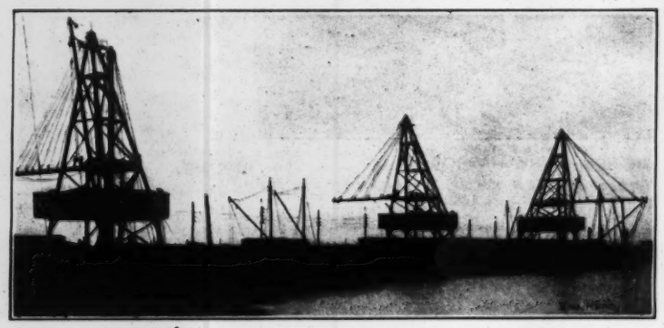

Fig. 6. Tower Cranes on the Greenville Docks of the Pennsylvania R. R.
(Bayonne, N. J.).

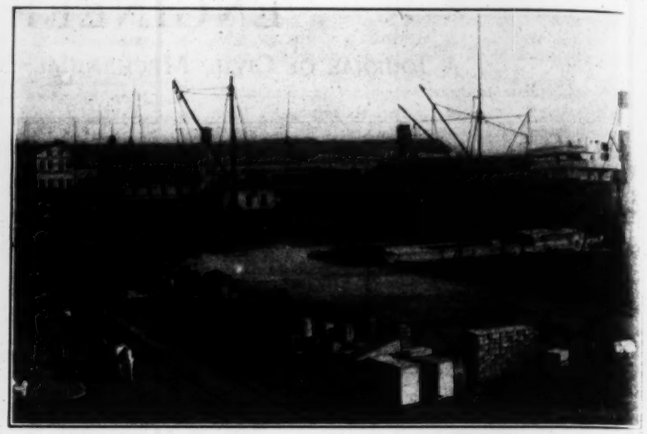

Fig. 3. Freight Storage Along the East River, New York City.
(No handling appliances used.)

Fig. 5. Gantry Jib Cranes on the Dock, Hamburg, Germany.
(Note the hand truck, which still does much of the work.)

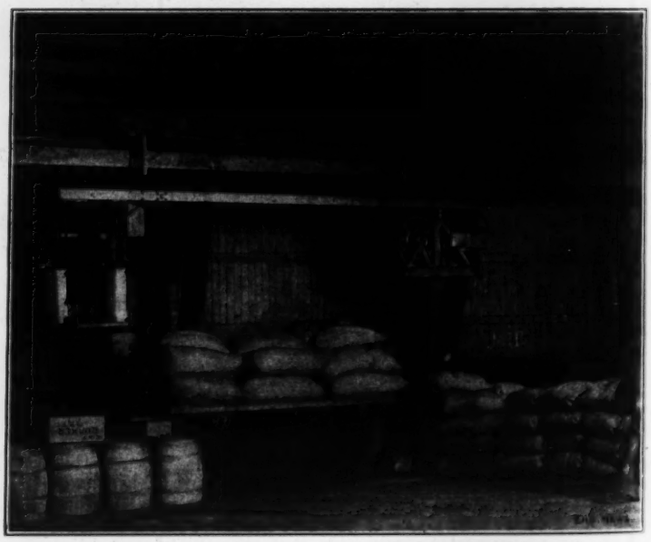

Fig 7. Electric Trolley Carrying a Truck in a Pier Shed.
(This is able to transfer only lengthwise of the shed.)

FIGS. 2 TO 7. VIEWS IN SOME SHIPPING TERMINALS.

relative proportions of house, transfer or team freight.

A most valuable collection of statistics on the expense of handling terminal freight is that furnished by Mr. Julius Kruttschnitt, Director of Operation and Maintenance of the Southern Pacific-Union Pacific lines. These figures are of special value because the figures are given in detail. The cost of station labor per ton for the following stations is condensed as follows:

Portland, Ore.....	46.2 cts.	Sacramento, Cal...	33.9 cts.
San Francisco, Cal.	27.2 cts.	Denver, Colo.....	23.7 cts.
Kansas City, Mo..	33.5 cts.	Salt Lake, Utah..	26.1 cts.

These are average prices and include both house and transfer freight.

From the above figures, and many others, the cost of handling package inbound freight is about 40 cts. per ton; outbound 35 cts. per ton; transfer 23 cts. per ton; and team freight about 4 cts. per ton.

If the freight should be all of one kind, as cement, the cost per ton will vary from 11 to 15 cts. Cargo freight on the New Jersey water front averages about 30 cts.

In 1906, the freight tonnage carried by the railways was 1,600,000,000 tons. To-day it is at the rate of 1,800,000,000 tons. Most of this has to be handled twice, once at the sending and once at the receiving point. For the L. C. L. or package freight there is often a third or fourth handling at transfer stations. This includes all kinds of freight, bulk and package.

The writer believes that the terminal expenses can be largely reduced, both in railway and in dock transfer handling. A saving of only 5 cts. per ton on the average for handling at each

rminal (including transfer freight, but not coal ore), would amount to nearly $200,000,000 per ear for railway freight alone (not including ater-borne freight). These figures of saving e believed to be conservative.

From a careful analysis of the results achieved mechanical methods over manual labor, the llowing savings might be expected: On house pier package freight, both outbound and in- und, 20 cts. per ton. On transfer pack- e freight, 13 to 16 cts. per ton. On inland vers, for miscellaneous freight (now handled by e roustabout method), the above saving would greatly increased, at least doubled, probably ore. Without economical freight transference etween vessels and shore, most of the advan- ages of water transportation would be lost.

The preceding figures as to the saving by me- hanical freight handling are believed to be con- ervative. They are based upon the results at- ained at manufacturing establishments, where many overhead electric carriers or telphers have been in operation for years, handling boxes, bar- rels, and all classes of freight, as well as from the telpherage plants at piers, both abroad and in the United States. Packages of all sizes, shapes and weights are being daily handled.

It may be stated broadly that in every case where sufficient freight is handled the net saving in cost of handling will be more than 25% on the money invested, after deducting all fixed charges, labor and power.

In each specific case the all-important question of investment and design should be determined by the engineer-in-charge in conjunction with experts on this subject, so as to secure the best combination of commercial forms of apparatus. The question must be decided on the basis of what it can earn per dollar invested. If an in- bound or outbound freight-house handling 1,000 tons of freight daily can save 20 cts. per ton with mechanical handling equipment, the annual saving would be $73,000. How much can the rail- road afford to invest to secure this saving? This must be answered by the President.

It is interesting to note that before Mr. Alex- ander Brown solved the problem of ore handling on the Great Lake the cost was $3,500 for dis- charging 10,000 tons by man and wheelbarrow. To-day the cost is less than $200 for the 10,000 tons.

Present Methods of Freight Handling.

To prove that the methods of handling now used are primitive needs only an inspection of some freight-handling points. It will be found that while hoisting appliances are often used, hori- zontal transferring is done by hand trucking al- most exclusively.

In the canal-boat terminal shown by the view on the first page, for instance, the difficulty of unloading and loading is evident from the picture. Each boat has to wait its turn, some- times a week or even more, to secure a berth next to the pier. All of the work is done by manual labor, except very heavy freight, when a horse does a part of the work. Is there any wonder that canal transportation with such ex- pensive terminal charges has so fallen off?

The views opposite, Figs. 2 to 7, show some interesting conditions. In Fig. 2 is the interior of a pier shed after a miscellaneous cargo had been unloaded. There is extreme disorder, gang- ways are obliterated and even the hand trucks used for shifting the goods are submerged in the ruck. The great delay and expense of hand- ling in this shed suggests themselves. Fig. 3 has a similar effect. The freight stored out in the street, many feet from the pier shed, had to be deposited there by trucking after being hoisted out of the hold, and must be handled again to load on wagons—three and possibly four hand- lings to get it from ship to wagon.

The dock view at Galveston, Fig. 4, exhibits the entire absence of mechanical handling appliances on shipping docks. Fortunately one railway track is close by the ship, but even to reach all the cars on this track, most of the freight must be moved long distances lengthwise, again by the hand trucks.

Fig. 5 shows how part of the transferring prob- lem is solved by cranes at Hamburg, Germany. Similar cranes are in very extensive use on con- tinental docks. In America practically none exist; as almost a solitary instance, the modern Greenville docks of the Pennsylvania at Bayonne (New York harbor) are equipped with tower cranes (Fig. 6).

Electric transfer hoists traveling on overhead tracks are used to some extent in freight-handling houses, but not nearly as much as in manufac- turing establishments. The view Fig. 7 shows a pier installation. The track runs along the side wall, and the carrier can transfer only longi- tudinally, so that manual trucking must do the transverse movement. A proper handling plant should be able to move its loads in both directions, covering an area rather than a line.

Mechanical Equipment for Eliminating Re- handling and Manual Labor.

PRINCIPLES.—The requirements for any satisfactory system of freight-handling are ap- proximately as follows: The system must permit loading and unloading simultaneously, or in case of transference between cars and ship, for ex- ample, it must permit loading in either direction or in both at the same time, with equal facility. Where the sheds are very long the machinery must be able to load or unload at any point or at numerous points simultaneously.

All movements should be without rehandling.

Every square foot of floor-space must be served in a single handling.

Vertical space must be utilizable for tiering.

The machinery should be able to hoist its load (from shed, car or vessel) without regard to height or water-stage, and place it where desired at any reasonable distance away (even several thousand feet if required), and there either tier it (in a warehouse) or lower it into open hatches, upon open cars, into open-top cars or alongside box-cars. All of the work of lifting, conveying and lowering must be performed entirely by power.

Continuous operation should be sought for, to avoid delay.

The conveying movement should adapt itself to any reasonable distance, height and alinement. Extensions should be possible without change in the existing installation.

No part of the transportation movement should be along the floor, and no floor space which can be used for other purposes should be occupied by the conveyor. There should be no interference be- tween the different elements of the transportation movement, nor interference of the mechanical plant with the handling methods previously used.

The machinery should be such that assorting and distribution, according to classification and destination, can be accomplished readily and quickly.

There must be reserve capacity, no congestion, saving of time in handling, and reduced cost.

The investment for the installation must be justified by the saving in operating expenses and the reduction in general expense. The cost of installation should be proportional to the tons of freight to be handled.

By properly designed installations meeting these requirements the cost of handling terminal freight can easily be reduced from the manual

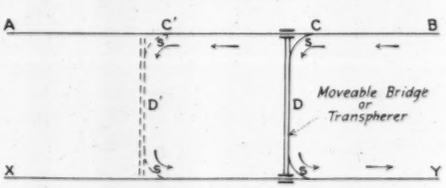

Fig. 8. Simplest Form of Space-Covering System of Electric Carriers.

labor costs to 5 cts. per ton and even less. What an enormous total of saving this would mean has already been stated above.

Applied to river traffic, suitable machinery meeting the requirements outlined would re- move several disabilities now met with. The disadvantages of the differences in level of the rivers at different seasons would entirely dis- appear because without perceptible additional expense, inconvenience or loss of time, the hoist- ing of 20 to 30 ft. farther would not be an ap- preciable factor. The delay at terminals could be reduced from one or two hours to ten or fifteen minutes, provided the barge, machinery and the installation were all properly adjusted to the requirements of the work to be done.

There are many companies in the United States engaged in the manufacture of conveying machinery, and it will be shown that by the combination of well-known methods of different manufacturers and those which have been proved to be successful in handling bulk material, it is an easy matter to arrange mechanical equipment to handle miscellaneous package cargoes which will produce an economy as stated above.

SPACE-COVERING CONVEYING INSTALLA- TIONS.—The three approved units needed to make up the equipment are the traveling bridge, the cross traverser or shop cranes and the electric traveler or telpher with gliding switches. The name "transpherage" will be used to distinguish this combination from what has already been in existence, to prevent confusion in terminology. Telpherage, already in use for a specific system, means far-carrying, while transpherage is cross- carrying or space covering.

The traveling-bridge is designated by the name "Main Transpherer," the cross traveler by "Cross Transpherer" and the electric carrier by "Electric Transpher" or Telpher. The main and cross transpherers can be driven at a high rate of speed in exactly the same way as traveling bridge cranes. The electric travelers or telphers are the actual load-carrying part of this equip- ment; the other elements furnish a universal multi-loop track system on which the carriers can reach any part of the space to be covered. The movements of the carriers should be clock- wise, so that there will be no interferenc and many carriers can be in operation at one time in close sequence. Each carrier can draw after itself a number of trailers, so that many tons can be hoisted and transported under the control of one man.

In a shop traveling crane or the common pe- destal traveling bridge there is but one carrying unit (or at most two or three), which greatly limits the capacity and range of the machine. With electric carriers on a movable track system, on the other hand, many loads are operated in close sequence simultaneously; this feature, with maximum speeds of hoisting and conveying, gives the greatest capacity and range at a minimum of labor and maintenance. The suspended track system, placing all machinery above the material handled, away from dust or grit, also tends toward low maintenance.

Some Applications of "Transpherage."

In the diagram Fig. 8 is shown the simplest form of "transpherage." The lines A B and X Y correspond to simple telpher tracks, and on them the electric carriers can run in either direction. The bridge D traveling lengthwise over them supports a cross track, with gliding jump-over switches S connecting it to the longitudinal tracks; this is the "transpherer." It has its own motor for traveling; while not supposed to move with transpher and load, it can do so if necessary. Position D' shows the transpherer after it has been moved to the left. A load can therefore be picked up anywhere within the space between A B and X Y and can be deposited at any other point in this space.

Fig. 9 explains how there may be two trans- pherers mutually connected upon the same tracks, each transpherer having two tracks and sets of switches upon each side, thus making four cross-overs. The electric transpher can go in any direction as per the arrows and from A to B past the switches S' S' to S S. It will be seen that the space-covering transpherers illustrate the simplest forms and embody no new single de- vice but a combination of well-known machinery.

It is important to remember that in any sys- tem of electric transpherage as suggested the freight may be weighed either when it passes over a section of the track connected with scales or by circular scales suspended between the car- rier and load.

In the more developed system Fig. 10, the two

transpherers have been bridged together by a movable "cross transpherer." This has greater flexibility. Suppose it is desired to move a load from A to M without moving the main transpherer. The cross transpherer C T is moved to the proper position, and the carrier can stop to deposit its load at M, leaving the track of the main transpherer unobstructed for the following carrier, which may pass on to D without being delayed.

More complex conditions call for more fully developed equipment, following the same type, however. Such a case is instanced in Fig. 11, showing the equipment of a freight-house bordered by two railway tracks on either side. The dotted lines are the walls of the building. Longitudinal transpher tracks extend along the inside and outside of the walls, with numerous connecting loops. Beyond the farther railway track on each side of the house is another longitudinal transpher track. Transpherers with cross transpherers are provided both inside and outside, covering the floor area and the railway track area in very adaptable manner.

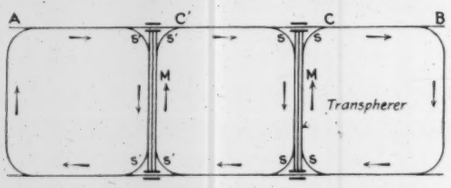

Fig. 9. A System With Two Double-Track Main Transpherers.

Application to Water Terminals.

Similar combinations of appliances are adaptable to piers and all kinds of water terminals. The closest parallel to the case of the freight house is found in a pier shed of the type common in American seaports. Sketch Fig. 12 exhibits the appropriate arrangement of carrier tracks for such a shed. The longitudinal tracks just outside of the side walls of the shed branch to loop tracks extending out over the vessel. The loops are cantilevered out by hangers, but can be raised up out of the way when desired. Further, they are movable lengthwise, to serve any part of the ship's length. The longitudinal tracks inside the building are connected by movable cross tracks, so that goods can be tiered anywhere within the shed.

A somewhat different arrangement would be preferable in the Chelsea piers, New York City. These are the latest of the municipal piers in New York harbor, but it is noteworthy that in their construction no provision for freight-handling on the pier has been made beyond manpower and the archaic hand-truck. The steamship's winch places the freight on the edge of the pier just inside the doors, after which there is no further mechanical handling. The manual labor of trucking and placing on drays is one of the chief items of expense in terminal freight handling, amounting to from 30 to 50 cts. per ton. Tiering is another expensive operation, and on this account much valuable vertical space is not used.

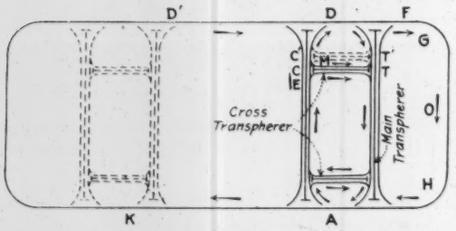

Fig. 10. A System With Double Bridge And Cross Transpherer.

The plan outlined by Fig. 13 provides mechanical equipment for handling inside the pier shed only, a concession to the existing method of hoisting by ship's winch from hold to pier. It is better to take the freight directly from the hold of the vessel, convey, deposit and tier without any rehandling, as in Fig. 12.

In a case of this kind the flexibility and ready expansion of the system is of particular value. The overhead tracks can be extended over a space in front of the shed to supply outside storage, or the cargo can be carried to any desired points nearby and placed directly on drays, cars or platforms.

Freight Handling on the Mississippi.

The virtual absence of freight transportation on the Mississippi and its tributaries has been commented upon frequently. Lack of terminal facilities is doubtless one of the chief causes of this deplorable condition. Quoting from Mr. John M. Ewen, until recently Harbor Commissioner for Chicago:

> There may be many causes for the absence of traffic on the Mississippi River, but it is my own judgment, arrived at after a careful study of the foreign situation, that the principal causes are the lack of proper terminal facilities along the river, and the failure to cooperate with the railroads. At most of the river towns the wharves are inadequate and the facilities for handling goods primitive in the extreme. Hand labor is relied upon almost entirely for the handling of freight. Usually the railroads do not connect with the boat landings.

In an article by Mr. George C. Sikes, expert for the Harbor Commission of Chicago, are given as cogent reasons for the disappearance of traffic from the river, the lack of terminal facilities and the absence of railroad cooperation.

In Engineering News of Dec. 2, 1909, Mr. John L. Mathews says:

> What is needed to make traffic profitable even in the unstable channels which we now possess is the practical development of boats suitable to the rivers, and terminal facilities which eliminate the (great) expense of transhipment of freight.

He states that handling freight by roustabouts in the old-fashioned river way (illustrated by Fig. 14) costs from $1 to $15 per ton.

Major Cassius E. Gillette has remarked that the great reason for the decadence of traffic upon the Mississippi is the cost of handling freight. Another difficulty is that the Mississippi River fluctuates 30 or 40 ft. in height while its shore line is advancing or receding upon the sloping banks by many hundred feet (and much more in unfavorable locations). He states that these costs of transhipment form so large a percentage of the total transportation cost, that the amount of water-borne traffic is becoming more and more limited.

A TERMINAL HANDLING PLANT FOR ST. LOUIS.—To show by a single striking example how the proposed electric carrier system would adapt itself to the work along the Mississippi River, the sketch Fig. 15 is offered. This picture is only to give the general idea, leaving out all details which can be omitted, and is not submitted even as a perspective drawing. Mr. Wilbur T. Trueblood, of St. Louis, made a most excellent view of the river front for the Civic League of St. Louis, and the conveying and hoisting machinery was inserted by the writer in his picture upon the levee, which had been left vacant. It is not necessary to wait for the improvements illustrated in the picture, as the machinery can be as advantageously and as readily installed under the present conditions of the water front.

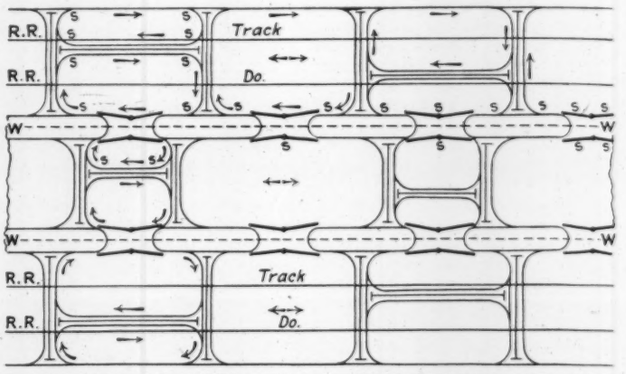

FIG. 11. HANDLING SYSTEM FOR A FREIGHT-HOUSE WITH FOUR TRACKS ALONGSIDE.

In explanation, the small loops in front move parallel with the direction of the river, and can be centered over any portion of a boat or barge. These loops are also hinged so as to be raised to clear any obstruction upon the vessel when the river is in its highest stages. As many loops can be placed above the vessel to be un-

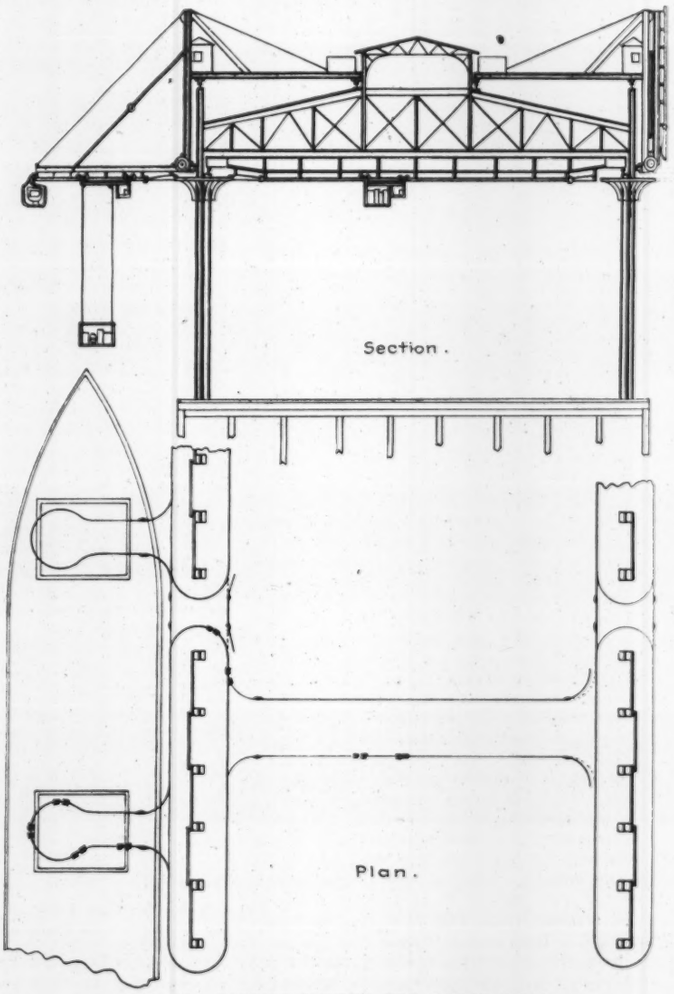

FIG. 12. CARRIER SYSTEM FOR A PIER SHED.

loaded as can be used advantageously. Upon each loop, several electric carriers or transphers can hoist simultaneously and carry away the load. The number of loops with the many transphers makes the work almost continuous. The number of transphers and trailers can be proportioned to the work. Each electric carrier or transpher can draw along a number of trailers, four or five, the hoisting and conveying being under the control of one man.

Although not shown in the drawing, at the inner side of each loop is a switch, the inside end of the loop being supported independently of the main circuit tracks, so that transphers can pass by the loop without traversing it and without interfering with transphers upon the loop.

The middle or cross tracks are also movable transpher tracks, so that when in different positions every foot of space upon the levee can be served. Transphers are shown in various places upon the tracks, loops, circuits and cross movable tracks.

The tracks are so elevated as to allow the bottom of the load to be about 10 ft. above the freight deck of a vessel at the highest water.

In unloading a vessel, the transpher, after the load is raised sufficiently to clear any obstructions, traveling in the direction of the hands of a clock, passes off the loop upon that portion of the main circuit track nearest to the river, then passes around the curve at the end of the circuit track, then traverses the cross track, and at the proper place is deposited, or else is carried farther on to cars or drays or into the warehouses, or to any intervening space.

The load can be carried over the switches between the various circuit tracks the whole length of the levee, or to any car which may be placed anywhere in front of the esplanade or under it. In other words, it is universal, for a load without any rehandling can be taken from any vessel in front of the levee and carried to any point in all of the space shown, or to the warehouses beyond, or from any one vessel to another, and the reverse of all these movements equally well. If any of the above movements be not desired, the structure could be simpler, but it seemed best to illustrate that everything could be done which could be possibly requested, rather than show limited movements. Pathways for passengers were omitted in the drawing, for clearness, but provision is readily made for them. There will be many electric trailer or carrier hoists operating at the same time upon the same vessel, and as soon as one trailer hoist has lifted its load and moved a few feet, another will take its place, so that there will be no delay and the process will be almost continuous. Many can be in operation upon one unit structure and they can be concentrated where desired.

The cost of operation will be reduced from 45 cts. per ton for package freight to 5 cts. The time of unloading, if the steamers and barges are so constructed as to secure the best results, will be reduced to one-sixth of the present time. Further, all movements are independent of the height of the river.

It is feasible to construct and equip small inexpensive piers at the smaller ports of call along the river. Their cost and size would be proportioned to the tonnage of the landing. They would be operated by electric current from the town's central station or from the steamer's dynamo. On account of the hoisting feature of the carriers, the handling of freight would be independent of the stage of the river and of the distance from shore to deep water. Loading and unloading would be conducted at the lowest cost known.

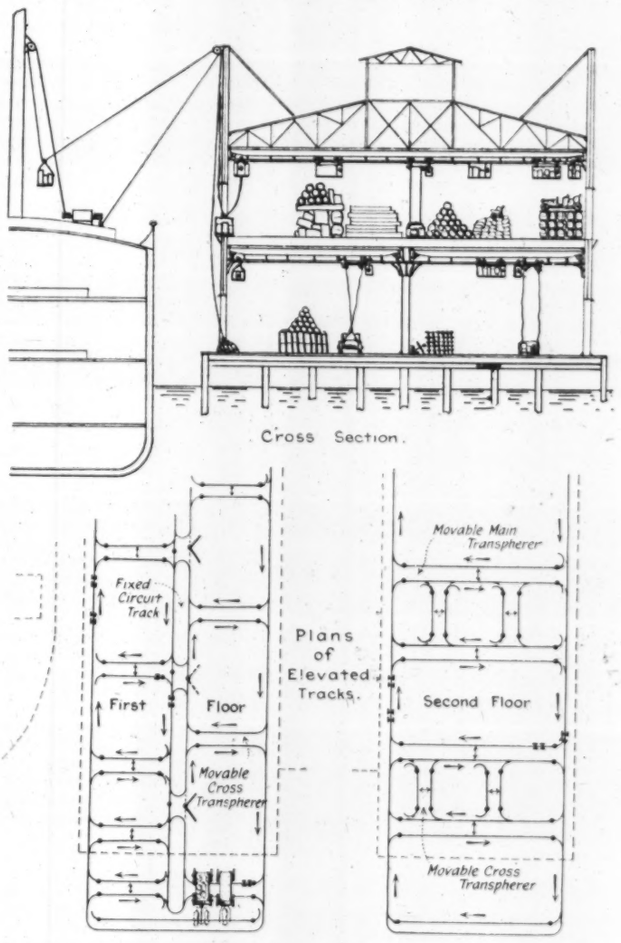

FIG. 13. INTERIOR CONVEYING EQUIPMENT FOR CHELSEA PIER SHEDS, NEW YORK CITY.

The success of these installations is tied up intimately with the nature of the transportation system on the river. This subject requires some consideration at this point.

NEED FOR AN IMPROVED RIVER TRANSPORT SYSTEM.—While, as already shown in several quotations from authorities, the lack of terminal facilities is the chief weakness of Mississippi River transportation, yet a satisfactory solution of the handling problem requires also an improved method of conducting transportation. To illustrate, the special board of U. S. Army Engineers says in its 1909 report on the river:

> In order to put the Mississippi River Valley waterways, as regards facilities of transportation, on a par with the railroad systems of the valley, which have branches or sidetracks to every city or town within easy reach, it would be necessary that the box cars of railroads should be represented on the river by barges for the entire river system, so that one or more barges could be loaded at factories and freighted along the river in large tows, to be later collected at depots at the mouth of each tributary, where new tows could be assembled for through towage to their final destination, each barge, at the end of its route, delivering an unbroken cargo to the consumer. Such condition is practically achieved in Europe by the great number of its light-draft barges and the great number of small harbors or havens scattered along its rivers and canals.

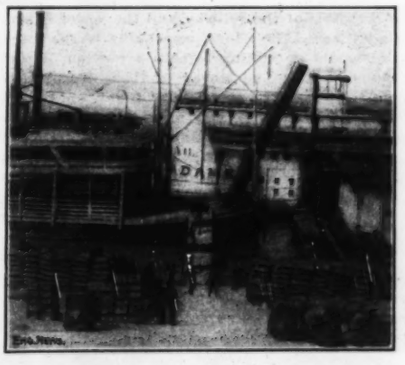

Fig. 14. The Present River Way: Roustabouts Loading a Steamer at Memphis, Tenn.

There has been developed upon the shallow tortuous German rivers, where there is considerable difference in the rise and fall of the water and also swift current, a type of barge called the "Rhine boat." These boats are made of steel, and some carry as much as 3,500 tons. They are of shallow draft, 3 ft. to 10 ft. Some have their own power and draw a train of barges not so supplied. Those without power are not expensive to build and at Rotterdam such boats do a great warehouse service, holding the merchants' stock a year or more if necessary, ready to deliver at any time and place desired. The cost of these barges when compared with the cost of terminal warehouses, including the purchase of expensive water front property, is often in favor of the barge, all conditions of location and terminal charges being given due values.

From the economical results achieved in Holland and Germany and the experience upon the Mississippi with bulk freight boats it seems as though similar barges, either equipped with power or towed or pushed by suitable power boats or power barges, would be the best adapted to the river conditions and to quick loading and unloading.

To adapt the Rhine boat to quick loading and unloading, the interior of each boat should be divided into removable sections of different capacities, the sections being so constructed as to be collapsible and to be folded flat so that extra sections can be readily stored for immediate use. One or more sections could be loaded for delivery at any port of call, and as soon as the boat arrives at the pier the sections could be hoisted and conveyed to the shore or into the warehouse, and another previously-loaded outbound section put in its place.

The transportation system as well as the terminal handling system must be designed to get the greatest possible returns from the floating stock. Time is the commodity which during the past few decades has experienced the greatest advance in price. It is therefore necessary for the barges to make the trips in the shortest possible time consistent with safety and cost of power. There can be no leisurely traveling and the cargo must be transshipped with the greatest speed.

There are many small ports of call which if properly served will develop into towns of importance, and that within a short period. A decrease in transportation expenses not only facilitates commerce, attracts many inhabitants, but creates commerce and manufacture. This reacts upon the larger cities, and they grow in proportion, the smaller towns and villages acting as feeders.

Barges of light draft should be employed to develop the transportation on the small streams, which, in relation to the main river trunk line, should serve the same purpose as branch lines do for railroads.

FREIGHT-HANDLING FACILITIES AT SMALL LANDINGS.—In laying out the landing and handling facilities for the smaller way ports, the location of the piers should be carefully selected with a view to security against the scouring action of the river. Those places where there has been little change in the river bed and banks for many years past should receive preference. There are numerous situations protected by points

of land from the action of the current, and generally these would be used.

With proper mechanical transference facilities, the time of loading and unloading can be reduced from an hour to ten minutes. More steamers will call daily at the small landings, and traffic will increase on all parts of the river system.

The method of constructing landings secure against destruction by river action would vary with the individual case, but generally speaking would consist in driving a few piles at a sufficent distance from the shore to secure a proper depth of water for the barges at any stage of the river. The piles are driven in the form of a T with the stem extending from the center towards the shore. Reinforced-concrete piles seem to be far superior to wood in soft bottoms and shifting river beds, and are especially serviceable when the lower ends of such piles are bound together with other reinforced bindings.

Upon the piles or extensions is erected the conveying and hoisting machinery. The barges are

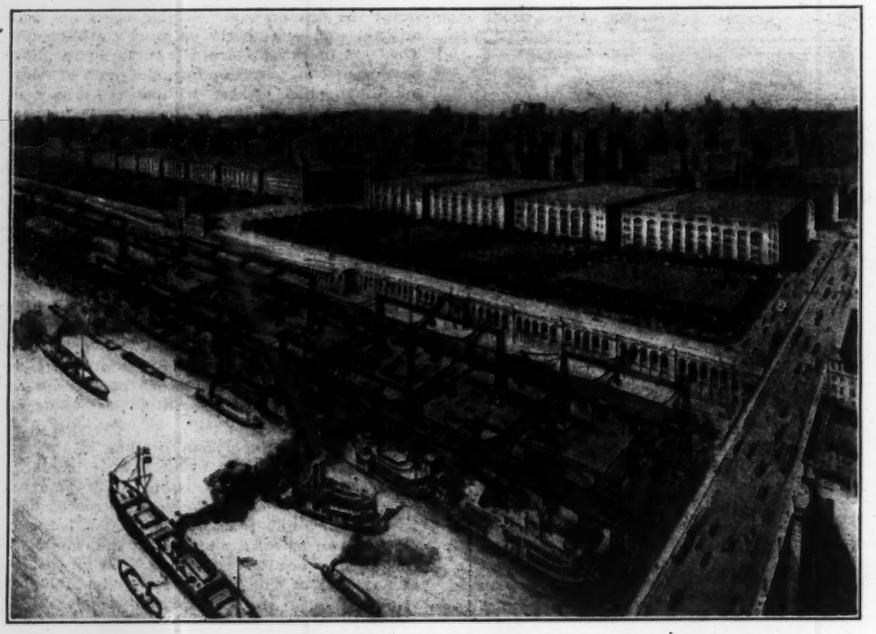

FIG. 15. SKETCH OF "TRANSPHERAGE" SYSTEM FOR LOADING AND UNLOADING VESSELS AT ST. LOUIS.

(Drawn by H. M. Harding on W. T. Trueblood's sketch view of an improved river front for St. Louis.)

moored along the outside piles. If the river be low, it means only a few feet extra hoisting.

At the smaller settlements, a small portion of the space, 15 or 20 ft. square, is boarded or cemented over for the wharf platform, with a foot-path to the shore, which high-water shore may be at times several hundred or even thousand feet from the outer piles.

The conveying trackage would extend in a loop above the outer platform and out over the boat (as in the pier plants shown above), and thence back along the pile structure to shore, or into warehouses, etc. In operating the system, as soon as the load is hoisted, it is conveyed to the bank, even though quite far distant. There is, however, no delay for the barge, as other electric carriers are ready to take the place of the one conveying, and few or many such carriers can be in operation at the same time. The suspended track forms a continuous loop, as in the installations sketched previously, so that maximum capacity is secured.

The simple form of pier construction is only intended for the smaller villages or settlements along or near the river front. For cities, each installation is an engineering question to be worked out according to local conditions.

These suggestions are given to show the simplicity of construction when electrical hoisting and conveying machinery is installed. They suffice to make evident, however, that the rise and fall of the river is no longer a serious objection, and that the long delays incident to the roustabout method of freight handling now practised can be avoided with great saving of operating cost, at small outlay.

Local Organization for Terminal Improvement.

Judging by what is now being accomplished in Europe in the handling of miscellaneous freight by boards of dock and harbor control, together with information derived from his own experience as well as from American railway and steamship engineers, the writer would unhesitatingly state that for the best interests of a community the direction of terminal facilities should be in the hands of a specialized board, public or private.

It would add greatly to the efficiency, utility, value and popularity of river transportation, if, in addition to supplying docks and temporary storage sheds, the board, in some way, public or private, should provide storage and other warehouses for various kinds of goods where stocks may lie for almost any length of time, the merchants paying a reasonable storage.

If a merchant could have a full barge load, or even less, but more than he needs for immediate consumption or sales, stored and held for him at a low cost, which he could draw upon as he needs, by such a system he could secure his stock of goods much more quickly than having them sent by rail. Rates of storage should be so adjusted that the cost of storing goods or stock for a considerable period would not amount to so much as the difference in cost between the freight rates of the railway and the water barges. In addition to the above, merchants in the larger cities would be willing to ship a portion of their surplus stock to be stored in these warehouses, from which local merchants could obtain the goods, immediately, even more quickly than by rail, the Terminal Warehouse Board acting as an intermediary, and by proper insurance, securing the city merchant against loss. This has been developed in many phases in Europe and with most satisfactory results, and also with certain commodities in this country.

There is scarcely a river or seaport city of importance in Europe which has not either expended large sums, loaned its credit or granted rights by which loans could be secured for the development of terminal facilities.

The amounts expended at the following cities either directly or through dock or harbor boards, or by private capital or by combinations of the above, are of educational interest. New Y Boston, Baltimore and other cities of the Un States are also expending large sums.

	Amount expe to July, 190
Liverpool, England	$150,000,00
Manchester, England	85,000,00
Tyne River Ports	87,000,00
Bristol, England	25,000,00
Glasgow, Scotland	44,000,00
Havre, France	42,000,00
Antwerp, Belgium	55,000,00
Rotterdam, Holland	30,000,00
Hamburg, Germany	100,000,00
New York, New York	95,000,00

Baltimore, since the fire, has been purchasi waterfront property and building piers, and fr the engineers' report the investment has prov to be an excellent one. Philadelphia, Boston, N Orleans, Los Angeles, Oakland and other cit are following as fast as practicable. It theref behooves the cities along the Mississippi and tributaries to look to the future and make pr vision for the soon-to-come development.

From the above and from the study of t situation from every standpoint, it seems, pr vided the movements between the shore and t vessel can be facilitated, not only in the cost b also in the time required for transference, tha one of the most important causes of the declin of water traffic would be removed.

Causes for the Decline of Water Transportation in the United States.*

The prevalent cause leading to the decline of water transportation is without doubt the railroad. The railroad corporation of large resources and facilities for its business successfully competes with navigation companies or individual boats with limited resources and facilities; and, competing, naturally does not enter into such relations with its competitor as to increase the business of the latter, declining to prorate, or to recognize through bills of lading.

The lower boat transportation rate does not measure the cost of water transportation. To it must be added charges for wharfage, teaming, and insurance; boat transportation on smaller streams is characterized by exposure of merchandise to the elements while on the bank awaiting or discharged from, the boat; shipments transferred to or from rail routes must be handled in detail; time schedules affecting passenger traffic deranged often by low water and at times by high, are frequently uncertain; freight, on the contrary, is often delivered more quickly by water; capacity of boats may be insufficient to provide transportation as needed; recompense for damages to freight in transit difficult to determine in amount or to collect.

Enumerating the above serves to accentuate the advantages of rail transportation even at a higher first cost. In place of wharfage charges, and exposure of merchandise to the elements, is the railroad freight house, or it may be the car on a siding, minimizing or even abolishing teaming. Carloads are transferred from one line to another without handling of freight; less than car loads, without teaming. Increase in freight is met by increase in cars; time schedules are independent of water stages as a very general rule.

But water transportation must contend with not only the greater facilities of rail, but also with rail rates so low as to make movement of freight by water unprofitable.

Railroads have also caused a decline in water transportation by centering such transportation about special points with greater facilities, natural and artificial, for larger vessels. Examples of this are to be found on the New England coast; and farther south, Norfolk has displaced Richmond and West Point. And here it may be fitting to note that water transportation has its fullest development on the Great Lakes and in the waters of and along the coasts of the United Sates when forming links in a chain of joint rail and water traffic.

But the essence of this fullest development is a capacious waterway; and this develops another cause for the decline—the intermittent character of the work of improving waterways. Contrast the improvement of the Ohio River with the construction of the Panama Canal. Both works are covered by comprehensive plans for definite results; but for the canal, appropriations are limited only to the extent of their possible due use.

But having in mind the Mississippi River it does not appear that when navigable depths are available, they would be utilized to the extent of the greatest possibilities afforded. Streams are not used to their fullest or best advantage. The demand is often for greater depths, instead of adapting draft of boats to prevailing depths.

*Memorandum of the Board of Engineers for Rivers and Harbors accompanying the Report of the National Waterways Commission.

The Hudson Bay Railway Project.

The establishment of a port on Hudson Bay and the construction of a railway thereto to assist the development of the great Canadian Northwest is a very old scheme. During the past few years it has been revived on account of the remarkable rapid settlement of northwestern Canada. The fundamental objections to the project are due to its high latitude, and include (1) the short season of navigation (about three to four months) and (2) the difficulties and dangers of navigation due to ice. The entrance of Hudson Straits into Hudson Bay lies far north of latitude 60°, and navigation is endangered by ice floes, fogs and contrary currents even during the open season. Explorers agree that ordinary ships should not risk being caught here (at the Fox channel) later than the middle or end of October, although the ports on the bay may not be closed by ice until the middle of November or December. A vast amount of work would be required to locate and mark the best channels and sailing routes, and to establish lighthouses, etc., to insure a reasonably safe route for commercial navigation. The difficulties of inducing shipping or commercial interests to operate steamship lines under these unfavorable conditions must also be taken into account, in addition to the difficulty of effecting changes in established trade routes.

The geographical conditions of the Hudson Bay route are shown on the map, Fig. 1. The distance from Fort Churchill to Liverpool (passing north of Ireland) is about 3,200 miles, as compared with 3,000 miles from Montreal. One argument for the proposed route has been the congestion of railway traffic which at present occurs in handling the grain crop from the Northwest to shipping points on Lake Superior and to tidewater. It must be remembered, however, that railway development is proceeding very rapidly in Canada. Already three great trunk lines extend from Winnipeg westward as far as Edmonton, and eastward to Port Arthur, on Lake Superior, while the one line extending from Winnipeg to the Atlantic seaboard will be paralleled in a few years by a second (and perhaps a third) line. Not only this, but in a few years there will be one or two additional lines to Pacific ports from which grain may be shipped westward. These general routes, with their relation to the proposed Hudson Bay Ry. are shown in Fig. 2.

It is to be noted that until within the past few years the Hudson Bay Ry. has been projected as part of a commerce route starting from Winnipeg, which is already the starting point of all rail and rail-and-lake routes to the seaboard. With the great development of the Northwest and its railway systems, however, an important change has been made in the project by which Winnipeg would be eliminated and freight would be shipped by more direct rail routes from the northwest district to Hudson Bay. This is pointed out in the report of Mr. Butler, which is quoted below.

Under the conditions noted it seems hardly probable that the benefits afforded by a Hudson Bay route can warrant the expense involved in its development. With shipments ceasing early in October, much of the grain going by this route would require to be stored in the elevators until the next season of navigation, or for nearly nine months. It is true that the government project provides for special locomotives and car equipment to give a maximum capacity, but it seems doubtful whether this could be utilized to advantage during the long periods between the rush periods of the grain traffic. It is true also that some local traffic is predicted, as well as exports of cattle and imports of coal in addition to the grain traffic. But these conditions hardly seem to warrant the construction of railway and harbor works at an expenditure of some $30,000,000. In this connection we refer to an article in our issue of June 23, 1908 (p. 695).

FIG. 1. MAP SHOWING THE GEOGRAPHICAL RELATIONS OF HUDSON BAY.

As a result of insistent agitation, however, the Canadian government decided in 1908 to have surveys made for a railway to Hudson Bay ports. The Canadian Northern Ry. has a line from Winnipeg to Prince Albert (on the Saskatchewan River), by way of Dauphin, and from Hudson Bay Junction, on this line, a branch has been built northeast to "The Pas," which is the starting point proposed for the Hudson Bay Ry. This is where the river turns southward into Cedar Lake and Lake Winnipeg. The Grand Trunk Pacific Ry. also proposes a line northwest from Regina, which would reach the same point. Other lines have been proposed to give direct connection with different points on the railway system in the Northwest. The Hudson Bay Ry proper may be considered therefore as commencing at the Saskatchewan River at "The Pas."

In the fall of 1908, Mr. John Armstrong, M. Can. Soc. C. E., was appointed chief engineer and preliminary surveys were carried on during the winter of 1908-9. Notwithstanding the severity of the climate it is stated that surveying can be done more readily in winter than in summer. In winter the swamps are frozen and there are no insect pests. Five parties were organized, aggregating about 110 men. They commenced work in September, 1908, and completed the railway survey work by the following April and the harbor surveys in August. The cost was about $124,760, for the former and $23,640 for the latter. A large part of the cost was for the transportation of supplies to the parties. Mr. Armstrong's report says:

> The experience of the Canadian Northern and Grand Trunk Pacific seems to indicate that it usually costs from $300 to $500 per mile to secure a final location in such country as this. During the progress of our work much information has been gained relative to transportation routes, which will enable us to greatly reduce the cost of supplies in future, and although the preliminary work has seemed costly, I do not expect that the cost of the final location will be greater than that usually obtained in such countries.

For the Churchill route (477 miles) the first 120 miles would be comparatively level country, with a considerable amount of swamp; the next stretch of 120 miles would be in granite country, involving a number of rock cuttings. The heaviest work would be in the third stretch of 120 miles, which includes the rise between the basins of the Nelson and Churchill rivers, with heavy rolling country which necessitates considerable development of the line to keep the prescribed grades. On the fourth section the earthwork will probably be light, but the engineer suggests that the crossing of the tundra or low barren swamps bordering on the Bay (70 miles) may prove more expensive than the easy profile would indicate. The grades are 0.4% against northbound traffic

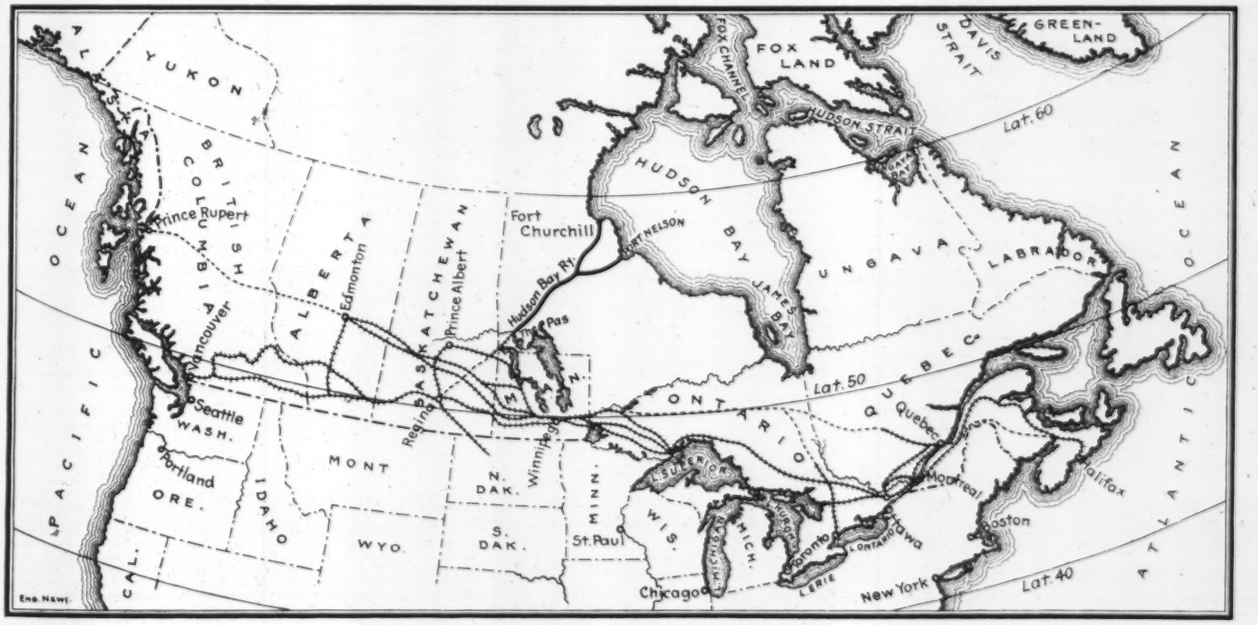

FIG. 2. MAP SHOWING THE RELATIONS OF THE HUDSON BAY RAILWAY TO THE CANADIAN RAILWAY SYSTEM AND CANADIAN PORTS.

and 0.6% against southbound traffic. The curvature averages 10° per mile. The Port Nelson route (410 miles) diverges from the other route near Split Lake, about 120 miles from The Pas; it does not strike the barren lands, but is in timbered country throughout. The maximum grades are the same but the curvature averages only 5½° per mile.

The Churchill route would have to be operated in four locomotive divisions of about 120 miles each; but on the Port Nelson route (owing to the easier grades) the engines could operate three divisions of 135 miles each. Thus five engine terminal facilities would be required on the former and four on the latter route. The estimated cost of the railway is summarized below. It provides for passing tracks and telegraph stations at intervals of five miles, water stations at intervals of 15 miles, and roundhouse and shop accommodation sufficient to care for the equipment necessary for 32 freight trains and one fast passenger train per 24 hours.

	Churchill route.	Pt. Nelson route.
Construction, including bridges, track (80-lb. rails), water stations and telegraph line	$11,351,520	$8,981,800
Construction cost per mile	23,797	21,905
Stations, and buildings, roundhouses, repair shops, coaling plant, warehouses, 2 grain elevators, yards, etc.	7,757,152	7,444,540
Total railway	$19,108,672	$16,426,340
Locomotives and rolling stock	9,000,000	9,000,000
Harbor work	6,675,000	5,065,000
Total, including equipment and harbor work	$34,783,672	$30,491,340

The Port Nelson route is considered the preferable; it is shorter, the construction work is easier and the port conditions are better. A fair proportion of the route is also considered available for settlement, while there is no probability of settlement on the Churchill route north of its junction with the Port Nelson route.

The traffic probabilities are reviewed as follows by Mr. M. J. Butler, Deputy Minister and Chief Engineer of Railways and Canals, in his general report accompanying the report by Mr. Armstrong.

The crux of the matter is: what business can be handled by such a railway, and of what value is it likely to be to the country tributary to it? For all practical purposes the city of Winnipeg is as close to Lake Superior at Fort William as The Pas is to Hudson Bay at Port Nelson, hence they may be compared as radiating points. A line drawn from Dauphin, Man., in a southwesterly direction passing through Weyburn, Sas., separates the tributary territory. Practically the whole of the province of Manitoba, and about 11,000 sq. miles of the southeasterly corner of Saskatchewan, is tributary to Winnipeg; the whole of the remaining area of Saskatchewan and Alberta belonging to The Pas. This immense district is equal in area to the states of North and South Dakota, Minnesota, Wisconsin, Nebraska and Iowa, where there is a population of about 10,000,000, and a railway mileage of about 50,000. I think that, square mile to square mile, the fertility of the northwest is at least equal to the states named.

Assume that the line is to be worked for all that is possible to be done. The grades are 0.4%. All trains are fully loaded and composed of 40-ton pay-load cars; and locomotives of the Mallet articulated compound type are to be used with a hauling power of at least 4,000 tons of pay load. A traffic of 32 trains per day is about the capacity of a single track; better than this has been done, but it is enough. With 16 trains loaded (64,000 tons per day), and making allowance for accidents and delays, say for 30 working days, we get 1,930,000 tons, or 64,000,000 bushels of wheat.

I assume that ships can be secured wherever there is sufficient business offered. It is apparent that at least nine per day would need to be loaded, or say 135 to 140, to do the business—allowing two trips to each ship. Any additional business taken to the bay would have to be stored until the following August (nine months).

Other sources of traffic possible to the line are: the exportation of cattle; the usual package freight to and from Europe; and the possibility of developing a reasonably large import coal trade. I believe it is practicable to lay down coal at Port Nelson from Nova Scotia at a cost not exceeding $3.75 per ton. The rail haul say to Saskatoon (as an average point of distribution) need not exceed $4 per ton, making the cost of the coal $7.75. At present, I believe, it costs quite $9 in the same territory.

Equipment for 32 trains per day of the character outlined will cost about $9,000,000; and means the providing of 108 train crews, 150 telegraph operators, 54 gangs of section men, shopmen, roundhouse men, superintendents, train and yard masters, etc., the greater number of whom are not likely to be required once the rush of the season is over. It appears, therefore, to be a difficult proposition for independent operation, and would seem to require to be worked by one of the large corporations, so that the men and rolling stock could be utilized the whole year. There is in Canada only one locomotive of the type described, and by using the largest freight engines now operated on western roads the trainload would be reduced one-half, and the capacity of the road in like measure.

It is apparent, however, that under any circumstances grain may be placed at the Hudson Bay on board ship as cheaply as at Fort William, hence the saving possible is 5 cts. per bushel, assuming that insurance and freight rates are equal at Montreal and Port Nelson.

The Unit System of Organization (Union Pacific-Southern Pacific System).*

By MAJOR CHARLES HINE.†

The primary object of this paper is to explain the details of the unit system of organization that is being installed on the Harriman Lines under the direction of Mr. Julius Kruttschnitt, Director of Maintenance and Operation, Union Pacific System—Southern Pacific Co.

THE DIVISION AN OPERATING UNIT.—An essential feature of the system for each unit is a senior Assistant, who, ranking next to the head of the unit, remains in charge of the headquarters offices and acts as executive officer. This senior Assistant is supposed to see (with common sense exceptions) all of the incoming and outgoing mail. If the other Assistants are present at headquarters, they sign their own mail before it passes over the desk of the senior Assistant for the latter's information. If an Assistant is absent from headquarters, he is represented, not by a Chief Clerk, but by a man of the wider experience of the senior Assistant who signs the routine mail in his own name. The absent Assistant is advised of the action taken, by such methods as common sense and courtesy may suggest. Matters highly technical are held for the return of the Assistant who is a specialist in that line.

The most difficult task in any organization of human endeavor is to correlate the activities of the workers on the outside with the necessary requirements of correspondence, records and accounting on the inside. The artisan in the shop, the traveling salesman on the road, the soldier in the field, the sailor at sea, the railroad man on the line, all have their troubles with the man in the office. When the inside man knows the outside game at first hand such differences in points of view are minimized, friction avoided, and therefore money saved.

Railway operation is the most exacting of human tasks. Like the conduct of a household, a farm, a hotel or ship, it is a continuous performance. Unlike those exacting occupations it must maintain its own communications over hundreds or thousands of miles of territory. So complex is its administration that chances should not be taken of losing money through half-baked decisions of partially trained office occupants. Most railway officials flatter themselves that when on the line they maintain a grasp on the office. Yet every hour in their absence action must be taken on matters which, apparently trivial in themselves, have far reaching results.

This statement is not a reflection upon the splendid ability and earnestness of railway officials. It is merely a recognition of the fact that a man can be in only one place at a time; that there are only 24 hours in the day and only 365 days in the year. The salary of one official is negligible as a percentage of the operating cost of the average unit. Accordingly the system insists that the second-best man of the unit, with practical outside training, shall stay at headquarters and sit on the lid. In some cases it has been found necessary to appoint another official to perform the previous outside duties of the Senior Assistant. In other cases it has been found that the outside work could be divided up among other members of the staff.

AUTHORITY AND INDIVIDUALITY.—In any system of organization the most important unit is the individual. It is claimed that when one man signs the name of another the first by so much loses initiative and individuality. A man's name is his birthright, his signature his patent of enlightened manhood. Long habit on railways has perhaps minimized the pernicious effect of unconsciously building up one individual at the expense of many. Such industrial feudalism, however, can no more parmenently endure than did the feudal serfdom of the middle ages. The unit system, therefore, insists that every man shall transact the company's business in his own name.

Addresses in official matters should be impersonal because of the possible difficulty of identification; because of the resulting elasticity in interior administration. One does not ordinarily address a letter to an individual attache of a firm, a bank, a hotel or a newspaper. He does not normally attempt to dictate who shall han his communication. He leaves that to the intellige and discretion of the organization that he is address Under the unit system communications are addres to the office—except when personal. The action tak however, is by a real live man, whose identity is n concealed. The position is assumed that the recipie of a communication has the right to know what pers is responsible therefor. The principle is established th except for a strictly personal staff, as for example private secretary, all persons report ordinarily to a hea quarters or an office and not to an individual. The a thority of such headquarters or office is always exercis by an individual. Authority, in an enlightened organiz tion of society or industry, should be impersonal. exercise is highly personal.

The application of the above established principle to t reorganization of an operating division requires that t Assistant Superintendent shall become the senior Assi ant. If previously there is no Assistant Superintend the Trainmaster or most probable successor of the S perintendent becomes the senior Assistant.

ABOLISHING BUREAUS IN THE DIVISION.—T next step in making the division a complete unit wi its head, the Superintendent, in effect General Manage is to move the division Master Mechanic and the Trav eling Engineer (Road Foreman of Engines) to the sam building with the Superintendent. The division sho as a sub-unit is left in charge of a General Foreman The old theory has been that a Master Mechanic if lo cated at the shops can better supervise the shop force It is believed that the volume of business and complexity of modern conditions have outgrown this theory. It found in practice that the Master Mechanic spends muc of his time in an office near the shop writing letters to the Superintendent, the Superintendent of Motive Power and other officials. Again, human nature is such that the Master Mechanic so located may unconsciously dwell on the plane of the division shop Foreman at the expense of the former's mechanical responsibilities along the road and at outlying terminals.

When this results his value as a *division official* is diminished.

The governing reason for locating the Master Mechanic and the Traveling Engineer with the Superintendent is not only to gain a closer personal touch. Such contact is largely a matter of personal equation and of training regardless of location. The main object is to eliminate red tape by making possible a consolidation of files in one office of record. It has been demonstrated that relieved of a bureau of unnecessary correspondence the Master Mechanic can and does spend more hours among his men whether in shops, on the road, or at terminals.

The revised standard circular of organization reads as follows:

.....RAIL..... COMPANY.
..... DIVISION.

OFFICE OF SUPERINTENDENT.

CIRCULAR NO. .....
..... 191....

Effective ..... 191...., this Division discontinues among its officials the use of titles—Master Mechanic, Division Engineer, Trainmaster, Traveling Engineer, and Chief Dispatcher.

The following named officials are designated:

1. Mr. E. F.....Assistant Superintendent
2. Mr. G. H.....Assistant Superintendent
3. Mr. I. K.....Assistant Superintendent
4. Mr. L. M.....Assistant Superintendent
5. Mr. N. O.....Assistant Superintendent
6. Mr. P. Q.....Assistant Superintendent.

They will be obeyed and respected accordingly.

Each of the above-named officials continues charged with the responsibilities heretofore devolving upon him, and in addition assumes such other duties as may from time to time be assigned.

Such of the above as are located in the same building have one consolidated office file in common with the Superintendent.

All reports and communications on the company's business, originating on this division, intended for the Superintendent, or for any Assistant Superintendent, should be addressed simply. "Assistant Superintendent" (telegrams "A. S."), no name being used unless the communication is intended to be personal rather than official, in which case it will be held unopened for the person addressed. It is intended that an Assistant Superintendent shall always be on duty in charge of the division headquarters offices during office hours. The designation of a particular Assistant Superintendent to handle specified classes of correspondence and telegrams is a matter concerning only this office. Each official transacts business in his own name, and no person should sign the name or initials of another. The principle to guide subordinate officials and employes is to be governed by the latest instructions issued and received.

Train orders will be given over the initials of the Train Dispatcher on duty.

The modifications of pre-existing organization and methods herein ordered have been carefully worked out to expedite the company's business by the reduction and simplification of correspondence and records. It is expected and believed that officials and employes will insure a successful outcome by lending their usual intelligent cooperation and hearty support.

Officials and other persons outside the jurisdiction of this division are requested to address official communications intended for the Superintendent or any Assistant Superintendent, "Superintendent, ...Division, ..." (telegrams "Supt."), without using the name of the Superintendent except for personal matter.

C. D.
Superintendent.

Approved:
A. B.
General Superintendent.

*Abstract of a paper read before the Western Railway Club at Chicago, Jan. 18, 1910.

†Special Representative, Southern Pacific Co., 135 Adams St., Chicago, Ill.

It will be observed that no distinct grade of Senior Assistant is created. The unwritten law is that whatever Assistant is assigned to the charge of the headquarters' office becomes the senior for the time being. It was originally intended that different Assistants should be detailed as the senior for certain definite periods. In some cases such a rigid rule may be necessary. The experience of a year indicates that the incidents and casualties of the service may usually be depended upon to let the situation work itself out. This is gratifying, since in such matters self-suggesting procedure is preferable to rigid rules. For example, if an Assistant sprains his ankle or mashes his foot the Superintendent can assign him to the office and send the then office man out on the road. Vacations and enforced absences afford the Superintendent an opportunity to cover the situation by a common-sense assignment. On one division the Senior Assistant was necessarily absent for some weeks. The Maintenance Assistant, who happened to be next in rank, was busy outside relaying the division with new steel. The third man, the Mechanical Assistant, had few troubles of his own in summer, and to him fell the opportunity to be broadened by a tour in the office. The Superintendent and the other Assistants, including the old Traveling Engineer, did the engine chasing. No circular was necessary, and there was less confusion than if two dispatchers had exchanged tricks.

AUTHORITY OF ASSISTANT SUPERINTENDENTS.—In order that their authority may not be restricted when meeting a given emergency it is necessary to give the division officials the uniform title of Assistant Superintendent, without the limiting effect of a descriptive phrase. If any one can coin title that will describe duties and not, under railway customs, restrict authority, such titles will be welcome. When a vacancy occurs the circular states, "Mr. X. is appointed an Assistant Superintendent vice Mr. Y." His assignment to duty by the Superintendent is verbal. If a Superintendent should find himself with an Assistant unfitted by temperament or experience to cope with a wider range of duties he could quietly restrict such Assistant to a prescribed limit.

The Assistant Superintendents when at headquarters, except the Senior Assistant, have equal rank. On the road they have the relative rank indicated by the circular or the current working time table. In case two or more find themselves together and an interruption to traffic or other emergency requires, the highest on the list takes charge and becomes responsible. The system forces more officials to assume responsibility and by so much increases the protection to the company's interests. More and more is heard about "this division," and "the company" and less and less about "my department."

Most division officials have welcomed the title of Assistant Superintendent as a real promotion and as an increase in opportunity. Some still feel the loss of a distinctive title. Time alone will prove that railroading has become great enough as a profession to carry its own marks of distinction and to permit of a properly balanced specialization along the lines of greatest aptitude. Men like Julius Kruttschnitt, James McCrea, L. F. Loree, Epes Randolph, J. W. Kendrick, F. A. Delano and W. W. Atterbury have not lost any reputation as civil and mechanical engineers because of their greater prominence as railway executives. For the same reason that a Chief Engineer blushingly accepts the title of Vice-President, a Division Engineer should modestly aspire to the position of Assistant Superintendent. This is one of the features of the unit system that it will take a generation to work out.

Eventually an official cannot hope to perform the duties of Chief Engineer, or Superintendent of Motive Power, until he has had experience in the grade of Division Superintendent. When Superintendents are selected from diversified sources this will be possible. An advantage of the uniform title of Assistant Superintendent is that, as in case of Vice-Presidents, it necessitates speaking of a particular official by name. When any official is away from his headquarters, he is addressed by name.

The unit system makes a distinction between superior or co-ordinate units and subordinate units. Employes address "Assistant Superintendent." If they addressed "Superintendent" there would be an implied obligation on the part of the Superintendent to answer. If his personal action is desired he must be addressed by name. Even though "Assistant Superintendent" is addressed the reply may be signed by the Superintendent himself. Subject always to his superior's wishes, the Superintendent makes his own office rules as to what he shall personally handle. It is up to him to see all, a part, or nothing for a given period, just as he sees fit.

Should the superintendent's letter call for further information from the employe, the latter's reply would still be addressed, "Assistant Superintendent." For all that the sender knows the particular official may be necessarily absent when the letter is received. Numerous old conductors have expressed their appreciation of the fact that a man knows what official has addressed him, and that it is no longer possible to be jacked up by a clerk using the name of an official.

Communications from superior or co-ordinate authority are addressed to the head of the unit, the Superintendent. In his absence routine matters for higher or co-ordinate authority are signed by the Senior Assistant who appends to his own title the explanatory phrase "For and in the absence of the Superintendent." Going down on the division no such explanation is necessary, as the authority of any Assistant Superintendent carries over the division itself.

THE SUPERINTENDENT'S SUPERIORS.—The Superintendent being in effect General Manager of his division is given charge of division stores as well as division shops. He must, therefore, obey the instructions of the General Storekeeper as well as the Superintendent of Motive Power. The General Storekeeper has thus placed at his disposal all the administrative machinery of the division. Instead of a lack of practical sympathy between the stores and the users of material, it is made the duty of the Superintendent and the Assistant Superintendents to watch material costs as well as labor costs, to help keep down interest charge on stocks as well as overtime.

It will be noted that the Superintendent, as the representative of all so-called departments on his division, has about as many superiors as he has Assistants. The work of these superiors is balanced by the General Manager. The scheme will not be fully effective until the unit system is applied to the general offices, making the General Superintendent, the Chief Engineer, the Superintendent of Motive Power, the General Storekeeper, the Car Service Agent, the Superintendent of Telegraph, the Signal Engineer, and the Superintendent of Dining Cars all Assistant General Managers with one consolidated office file, and their activities co-ordinated by a Senior Assistant General Manager at headquarters. Thus far only one general office, that of the new Oregon & Washington R. R. at Seattle, has been reorganized in accordance with this conception.

WORKING OF THE SYSTEM.—The number of divisions now reorganized is 21, with 11 still to follow. The number of Assistant Superintendents on a division varies from three to twelve. Every Superintendent has shown his ability to handle as many Assistants as the management may give him. The most gratifying feature of the reorganization is the fact that in all cases the talent at hand has been sufficient. No importations have been necessary. The incumbents of official positions have responded splendidly to the confidence reposed in their ability. Some divisions have gone farther than others. This always has been and always will be the case. Every one, however, has made real progress, some if it unconscious. The human element has been recognized. Division officials who from lack of early breadth of opportunity have not the qualifications for Senior Assistants are not required to fill the position. Their services to the company have been too faithful to warrant humiliation or elimination. Their grasp of present conditions is greater than could be that of student successors. When, in the course of nature, a new crop of officials matures it will be ripened younger but attain a fuller growth.

Consideration has been shown for the clerical forces affected by the changes. No individual has had his salary cut. As vacancies occur through natural causes salaries are readjusted; some increased, some diminished to meet the new conditions. All of these matters are left to the local officials. Principles are enunciated, suggestions made, but responsibility for details is left to the officials on the ground. The system means more officials and eventually fewer clerks. Probably by a cheeseparing effort enough clerks could be eliminated to offset such increases in official salary lists as have been found necessary. The management has felt that increased supervision will warrant the outlay. This liberal policy is justified by good business sense rather than by the prosperity of the Harriman Lines. The poorer a road the more money it should spend for supervision and the development of esprit-de-corps.

Formerly office work was grouped around officials. This resulted in petty principalities and bureaucratic administration. By tearing down some office partitions there were razed those figurative department walls, which so often operate to keep in the man who is trying to keep the other fellow out. Under the new conception the work is grouped by classes. The technical term among business experts is "The concentration and co-ordination of routine and related processes." At a small roundhouse a handy man may be machinist, boiler maker and car repairer. In a large shop for obvious reasons the boiler makers and machinists are segregated. So, in an office, stenographers may be pooled, accountants segregated and clerks concentrated for the general good of the office work rather than for the fancied importance of a particular phase.

LETTER-WRITING AND FILES.—The key to success in the unit system is a properly handled file room. It is given preferred attention and whatever force is necessary. When all the clerks of the division are pooled no difficulty is experienced in finding sufficient to handle the file room. William's Railroad Classification is being installed with a view to uniform filing.

As a general proposition officials at headquarters should not exchange written communications among themselves. Superintendents must apply this principle without hard and fast rules. For example the Superintendent of a heavy division being on the line some 200 miles from headquarters, very properly addressed a joint letter to each of his ten Assistants, calling their attention to a wreck he had just picked up and as the lesson to be learned enjoining upon them a vigilant enforcement of certain rules. It has been found possible to reduce the correspondence of divisions reorganized from 30 to 50%. Even with reduced clerical forces night and Sunday office work has been eliminated.

The great reduction is made possible by the constant presence of the Senior Assistant who is alert to discourage the letter writing propensities of headquarters. It is expected that when all the units under the Chicago office are reorganized there will be a net saving of at least 500,000 letters per year. Every letter costs a few cents to produce. Its retarding effect upon administration cannot be measured in money. Its dwarfing influence upon the individual initiative of the man below is likewise indeterminate. It is expected also that when the reorganization is completed numerous routine reports can be dispensed with.

SPECIALIZATION REMAINS.—It is not expected that a mere change of title or an assignment by a Superintendent will make a man a skilled mechanic or an experienced engineer. For technical questions arising on a division the most expert knowledge available will continue to be utilized. It is claimed, however, that as the average division official has been in the service at least ten or fifteen years, he cannot fail to have acquired some familiarity with the requirements of the various branches of the work. The old Trainmaster may as third-trick Dispatcher have ordered an engine taken down and towed in without awakening the Master Mechanic. By so much more should he with wider experience be able to say whether or not the company's interests are being best observed in the handling of a locomotive that may happen to come under his notice. The Mechanical Assistant cannot be everywhere and any help that his fellow officials can render the company should receive.

Conflict of authority is avoided by the common sense and courtesy of the Assistants and by the attention of the Superintendent. Nothing makes men so conservative as responsibility. It is claimed that the Superintendent on the ground is better able to decide these questions intelligently than is a hard and fast code formulated by a man behind a distant desk. What is construction to-day will be maintenance to-morrow. What is motive power at the turntable becomes transportation at the switch.

Each official continues responsible for his branch of the work until otherwise indicated by the Superintendent. The Maintenance Assistant is not allowed to plead transportation duties as an excuse for defective track. With him track must come first. When the train stops he cannot inspect track until it resumes. Meantime he may be able to minimize the delay by seeing that employes perform their duties promptly. He is not allowed, except for insubordination, to discharge employes on another Assistant's payroll. He is expected, however, tactfully and politely but forcefully, to insist that the rules be obeyed. The faithful old employes need only encouragement to perform their duties well. The young and inexperienced require constant supervision and instruction. Due to its great extent of territory a railway exercises less control over its employes than any other line of organized effort. The safety of lives and property demands the greatest possible intelligent supervision.

[The discussion of the paper was in substance a series of questions as to the working of the system in one point or another, with answers by the author. These answers make the preceding explanations of the system more clear, and therefore are abstracted below.—Ed.]

CONFLICTS OF AUTHORITY.—(Query: Is there not a likelihood of instructions being given by an Assistant Superintendent on the road, concerning a subject outside of his specialty, which would not agree with the intentions of the Assistant who normally handles that specialty?)

We feel, with our experience thus far, that our men, our officials, and especially the Superintendents, are strong enough to overcome that weakness. The answer is that the Superintendent maintains a balance. On some divisions we have had a slight conflict of authority. As a general proposition the Superintendents say to me—"No, we have more trouble getting our men to go to it, we have to urge them forward to take up other matters rather than hold them back." That has been the experience thus far, and that is not disappointing, for the reason that the system is new, and we prefer to have men get their bearings before they try to do too much. But there again the personal equation of the Superintendent comes in. We depend upon the Superintendent to maintain that balance. We say to the Superintendent in the beginning, "This is a test of your ability." If the conflict comes, that may be the fault of the system or it may be the fault of the man.

Elaborating a little on that particular point, what we are after is this; human nature is so constituted that we always defend the man below us from the man on the outside. No matter how arbitrary or unreasonable we may be, we resent the other fellow saying anything to "my man." If an old Division Engineer is riding on the rear of a train and he tells the flagman that he didn't go back far enough, if the flagman does not tell him to go to hell the Trainmaster will. The Trainmaster says, "Why, you are interfering with my man," and here is the way it works out. The Division Engineer reports that man, but human nature is such—and remember, gentlemen, organization is in a great measure a system of checks and balances against the amiable failings of human nature as well as a support to its strong qualities,—that the old Trainmaster constitutes himself an attorney for the defense, and after a considerable time, when pretty nearly everybody has forgotten about it, we get a bundle of papers back, and if anybody dropped down from Mars or anywhere else and looked them over he would have thought, "Why, what a dub they have for a Division Engineer on that division and what an admirable set of flagmen." The Trainmaster has unconsciously belittled the Division Engineer. We don't say the Division Engineer is perfect, by any means; he may have been wrong; but we do say that we would rather take chances on the judgment of that Division Engineer, who has been riding up and down the road for some months or some years, who has a larger view point and should know more about it than this young flagman, who perhaps has not yet soiled his first uniform. So that now we place the presumption in favor of the division official. Formerly the presumption was in favor of the other man, no matter how inexperienced, because he was in another so-called department.

OPERATING "LINE" AND TECHNICAL "STAFF."—(Query as to the place of the technical man, e. g., the Mechanical Engineer, in the system described.)

From the strictly military point of view there is a distinction between staff officers and line officers. A line officer is a man who handles men, and a staff officer is a man who handles things, and by things I mean to include technical matters, the professional side. A staff officer may handle other officers, but it is laid down, and as I remember it in the Revised Statutes of the United States, that a staff officer cannot command troops, except by express direction of the President of the United States.

The intention is to give those officials who have to deal with the rank and file a title which will carry authority. A Mechanical Engineer, as I view it, is a staff officer. My conception of it is that the Superintendent of Motive Power, whatever he may be called, is the man who deals with the working forces through defined channels. In the Unit System we change the channel through which he deals; he must deal entirely through the Superintendent. The Mechanical Engineer is his staff officer, a real staff officer, his most expert adviser, if you please; the man who will have charge of standards, of design and of highly technical and professional matters. But the Mechanical Engineer was not included in this list of Assistant General Managers for the reason that it was not felt that in the majority of cases he would be the man to get out and handle the working forces. It might be on some roads that he would, in which case I would say he should go in with the others. But the Mechanical Engineer maintains, if you please, a professional isolation on that question. There are a good many of these questions that, while some of us have very definite ideas, have not as yet been worked out, and a discussion of them in the concrete might be premature. But the general phase of the work is covered in what is known as staff, using staff in its strictly military sense.

Our old code of organization read in effect: "The Master Mechanic will report to the Division Superintendent, except that in technical matters he will report to the Superintendent of Motive Power." That "except in technical matters" left the door wide open. It was difficult to find any two gentlemen who agreed upon what were technical matters. We found that some mechanical men felt that the putting of a new shovel on a locomotive, or an additional bucket of sand, was a highly technical matter. Others did not. So we have given up in despair attempting to define those questions in advance. We put the whole thing up to the head of the unit, the Superintendent. We preserve the importance, and we claim we increase it, of the technical man, like the Mechanical Engineer, and the other technical experts that are employed on a railway. Our position is that the technical man by reason of his more thorough training and his in one sense broader professional attainments has unconsciously absorbed to himself certain authority, saying "This can't work unless I control it." Our position is that the technical man is doing his highest work when he can show the other fellow how to do it; that the specialist is needed in the stage of construction and installation, and that for everyday maintenance and operation the specialist must be prepared so to instruct the layman that the latter can meet the ordinary requirements.

THE LOSS OF DISTINCTIVE TITLE.—(A query raised the point that a Division Master Mechanic under the new title of Assistant Superintendent would feel that his chance for advance to General Master Mechanic or to Superintendent of Motive Power, or for bettering his position by going to another road, was reduced.)

We take this position: We say that our Assistant Superintendent is just as good and a little bit better than anybody else's Master Mechanic. This point would carry more weight were it not for this fact: the American Railway Master Mechanics Association has not among its general officers a single gentleman with the title of Master Mechanic. There are a variety of titles, but most of them are Superintendents of Motive Power. The Master Car Builders' Association, which has done such splendid work, does not have on its official list a single man with the title of Master Car Builder, and I don't think there are a dozen with that title in the country to-day. So that after all the title does not count for so very much, and if somebody will invent titles we will gladly welcome them that will be brief, to the point, and yet carry authority and describe duties. You will find that difficult. The more you study it the harder will you find it to do so, because if we have said that Mr. So-and-so is appointed an Assistant Superintendent in charge of the mechanical department, why, when he went down in the yard some day the yardmaster might say, "Well, now, the mechanical department stops over at that switch, and I don't understand what you have to do with me." That is what we want to guard against. But now when we have a blockade, instead of having to send two or three officials to one place, we hope that one man can perhaps go down and clean it up. If required by stress of weather or otherwise we can scatter our officials where they can do the most good. We have probably all of us been through blockades, we have probably all chased around engine houses at 3 or 4 o'clock in the morning, and we have heard a man say "Now, this is not up to my department, it is up to the other; my part is all right." And some railroads have gotten up a special blank to show whether the engine was ready first or whether the train was ready first, and there is a long argument as to how many hours the power was in service, and the result is that they chase the engines out on the road and they die because there is a blockade of trains there. We expect to eliminate this whole question of whether the train was ready first or the engine was ready first. We claim that the time of our officials is too valuable to continue to be taken up in these personal—that is what they amount to—these personal differences of opinion as to why certain things were or were not done. We want to move the train, and not talk so much about why it did not move. That is what we are all here for, is to move the train.

THE "DEPARTMENT" SPIRIT.—(Query, whether some other official than the existing Assistant Superintendent may not be the proper man as Senior Assistant.)

We felt that as we were just getting started it was better to take things as we found them. As in the case of a conductor or engineer, if we are a little doubtful of his ability to handle a particular run it is only fair to him to have a trial and let him see what he can do. We had one case of a man who had recently been promoted to be the Assistant Superintendent of a division, who had had rather limited educational opportunities, and the local people said: "Well, now, better not try him in the office, he will fall down." I rather encouraged his being tried. I said: "He stands for it, why not give him a trial?" And we found this, we found that some of the correspondence that man handled had a few grammatical errors, but we found mighty few errors of judgment; he had so much hard horse sense that he improved certain conditions very speedily.

But there might be reasons why some one else should be taken. One thing that has been against that, though, has been this: As far as the mechanical men are concerned, in some cases the Master Mechanic might have been a very logical selection for the Senior Assistant, but the Superintendents of Motive Power rather fought shy of that in the beginning; they are now coming across, but in the early stages they felt that the power would go all to pieces under this system, everything would be upside down, they could not put in another mechanical man for an outside Assistant Superintendent, so we had to take that condition as we found it. We have endeavored to avoid arbitrary action wherever we could, and if the mechanical men or the civil engineers have not had a chance, the fault perhaps is due to the heads of their so-called departments.

Gentlemen, I use the term "so-called department" advisedly. As I understand the organization of a railway, there are four departments. You will find that the organization and by-laws of most railways provide for four departments. First, the executive, legal and financial, usually presided over by a Vice-President, sometimes by the President himself. You have a corporate existence to build your road, you have money with which to build it, and you have a charter under which to operate it. Second comes traffic, because you must have business to justify your existence. Third comes operation, which handles that traffic, and operation includes maintenance and new construction; you can't very well operate a ro without maintaining it. And fourth comes accounti or auditing, which checks up the activities of the other the watch-dog of the treasury, as it were. We u loosely the term "department," and always will—I ha no desire to reform the language. We use the term Motive Power, Maintenance and Transportation a these other Departments, for lack of a better word. B after all they are branches or subdivisions of the fo departments.

ADJUSTMENT OF SALARIES OF ASSISTANT SU PERINTENDENTS.—We have taken these men ove bodily thus far with their old salaries, there have bee no changes in salaries, and naturally that has brough to a show down some of the existing incongruitie in favor of one department or another. What we have i mind is a form of treatment of that question by whic there will be a progressive increase of salary for lengt of service, starting a man when he reaches the officia ranks at a given minimum and working out a certai percentage of increase for each definite period, perhap each year of service. We feel that in the past railwa salaries have been too much a matter of accident, fr quently depending upon how many friends a man has o another road. He gets an offer and is raised to kee him, so that there is inequality in salaries. I think tha on that old and splendidly organized railroad the Penn sylvania such condition does not obtain. The man wh gets an offer can take it or leave it. What we have i mind is that a man will start in at a certain minimum of salary in the official grades, that of Assistant Super intendent, if you please, and that he can look forward a the end of every year of service to a slight increase i pay up to a given maximum. We can't promote every body; there are not vacancies enough, in the first place In the next place, there are some men who are admirable Assistant Superintendents who would probably not make good Superintendents, and it is only fair to them that they may know what to expect. A man who has a growing family to educate should know what to count on if he retains his particular grade.

In the Government service considerable stress is laid upon increase of compensation for length of service, and it does not work out as well there as it might. It sometimes leads to a man being a drone, he is too certain of his position. But we feel that on the railways we can impose checks enough against that, so that a man can know what to count on. If this can be worked out and defined, if a man gets an offer from another road, we simply say to him: "If you feel it is better to go, why go, God bless you; but if you feel that you want to stay with us, why, here is what you can expect; if you get promoted, the next grade pays so much; if you are not fortunate enough to be promoted, at such a time you will be getting so much money, and at 70 years of age you can count on so much pension, and so forth."

AUTHORITY OF GENERAL OFFICERS.—We hope to carry the system a step further [than reorganizing the divisions only—Ed.]. We want the Superintendent of Motive Power to be such a big man that if he goes out and decides an engine needs shopping to prevent her cutting her valves, or anything else happening, that he can order that engine run light to the shop, if necessary, without asking what it costs. At present if he orders an engine in, why, the Chief Dispatcher may hold her for one more round trip. If she has to go over two or three divisions to get to the shop, the Chief Dispatcher on the next division may steal her for a work train for a day or two. Our old code of organization read that on the divisions the Superintendent of Motive Power exercised a jurisdiction concurrent with the Division Superintendent. We now say, when we define it that the Superintendent of Motive Power as a general officer exercises a jurisdiction upon the division superior to that of the Superintendent, he is a real general officer.

THE FRENCH AUTOMOBILE INDUSTRY has, for some time, been passing through a severe crisis, due, in a very large measure, to the fact that the manufacture of mechanically-propelled vehicles had tempted too many investors of all classes, and had rendered a more than abundant supply of capital available for the indiscriminate financing of automobile companies and works. The general impression was that there would be a constant supply of buyers of cars; but the prices quoted and the types of cars built very soon showed that the moneyed classes alone could be reckoned upon as customers. Their numbers, however, proved to be comparatively small—quite out of proportion with the power of production of the new motor-car works.

At the close of 1908 the number of "pleasure cars" in France amounted to 22,250, with an aggregate of over 295,000 horse-power. Until the above date the French motor-car industry had developed satisfactorily. From the figures so far available the number of cars of all sorts in use at the close of 1909 throughout France amounted to 44,800, of a total of 569,000 horse-power. These figures show that the number of automobiles in use had progressed in 1909 in approximately the same proportion as in the former years, and would lead to the conclusion that the French motor-car industry was in a satisfactory situation. The development in the French demand has, however, not been sufficient to meet the expansion of the works. These would have required, in order to be at the present time in a satisfactory position, a far greater number of orders than they have received. The export orders have also shown a gradual falling off. —"Engineering" (London), Feb. 11.

The Relation of Forests to Stream Flow.*

By MAJ. WILLIAM W. HARTS.†

The claim has been made so often by the advocates of forestry that the deforestation of river drainage basins in recent years is now resulting in higher floods and lower low waters, that it seems worth while to examine some of these rivers to ascertain whether these assertions are founded on truth.

A careful study has been made of all the records pertaining to the two principal rivers under my supervision, viz.: the Cumberland and the Tennessee. These records refute so positively many of the statements of the advocates of forestry that the connection between deforestation and navigation can scarcely any longer be maintained on these rivers.

The Cumberland, with its tributaries, has its source in eastern Kentucky and Tennessee at elevations of about 2,000 ft. above sea level. The drainage area above Burnside, Ky., is 3,739 sq. mi., and above Nashville 11,600 sq. mi. As is to be expected, the slope of the river and the general grade of the country through which it flows are much steeper in the upper than in the lower portions, the average fall of the river surface from the mouth of Poor Fork to the mouth of Rockcastle River being 3.04 ft. per mi.; from the mouth of Rockcastle River to Burnside, 2.57 ft.; from Burnside to Nashville, .67-ft., and from Nashville to the mouth, .403-ft.

The Tennessee is formed near Knoxville by the confluence of the Holston and French Broad rivers. These tributaries rise in western Virginia and North Carolina at elevations of 2,500 to 3,000 ft. above sea level. The drainage area above Knoxville is 10,295 sq. mi., of which 6,438 sq. mi. belong to the French Broad and 3,857 to the Holston. The drainage area above Chattanooga is 21,418 sq. mi. The average fall of the Holston from Kingsport to the main river, a distance of 142 miles, is 2.54 ft. per mi. The French Broad, from Brevard, N. C., to Leadvale, Tenn., descends at an average rate of 8 ft. per mi.; while from Leadvale to the mouth its average fall per mile is 2.27 ft. From the confluence of these two rivers to Chattanooga (188 miles), the fall in the Tennessee averages .95-ft. per mi.

The country in the vicinity of the upper portions of these river systems is generally wooded, the areas of cleared and cultivated land increasing as we pass down the streams. The river bottoms are often highly cultivated, but the soil of the uplands is generally poor, and owing to the mountainous character of the country surrounding the headwaters these regions are of far less value for agricultural purposes than the valley lands lower down. The areas of cultivated land are increasing, however, and vast areas of timber land have been cut over within the past fifteen years, so that deforestation in these areas is referred to by the Forestry Bureau as already dangerous in extent and as increasing with alarming rapidity. They maintain that it is now affecting adversely the navigable condition of our streams, and that forest preservation is necessary if we expect to protect their navigability from injury.

Exact information as to the areas under forest cover at the present time is very meager, and many efforts to obtain even a close approximation were fruitless; so that the estimates of forested areas given herein are largely based upon conjectures. From the best information available, I should say that the proportion of the drainage basins of these streams under forest cover would now be in the neighborhood of 60%. The increase in cleared areas within the past 25 years, including tracts deforested for the sake of lumber, may perhaps amount to as much as 20%. From the census report of 1900 it appears that in Tennessee the increase in the areas of improved farm lands between 1880 and 1900 amounted to 1,749,394 acres; in North Carolina to 1,845,915 acres, and in Virginia to 1,584,692 acres. The changes within twenty years in the lower lands of these states have not been nearly so extensive as in the higher portions, and it may be assumed without much question that the greater part of this increase was at the expense of the forested areas about the headwaters of the streams under examination. The total amount of clearing in the southern Appalachian region is given by the Forestry Bureau as 24% (Report of the Secretary of Agriculture on the "Forests, Rivers and Mountains of the Southern Appalachian Region," 1902; p. 26); leaving an average of 76% still under forest cover.

The most active lumber operations in the upper drainage basins of these rivers have been carried on within the last twenty years, although lumber began to be cut in large quantities as far back as the early seventies. Lumbermen state that in 1906 far more timber was cut in these drainage areas than in any other year on record. Before the seventies the forested areas in the mountain regions were practically the same as before the advent of the white settlers, deforestation having been slight up to that time; so that a comparison of the river conditions from about 1875 to the present day should show what changes, if any, have resulted from the reported wholesale destruction of our forests.

In order to facilitate such comparisons I have had prepared a chart showing the rainfall records and river stages at three places on the Cumberland River, by months, and a similar one for the Tennessee River. [The charts are so detailed and so large a scale as not to be suitable for reproduction here—Ed.] The maximum and minimum gage readings at each locality for each month have been plotted and joined by a line, to ascertain whether any noticeable change has taken place in the height or frequency of floods during the period under observation, or whether any marked difference in low waters or their frequency could be detected. Charts have also been prepared showing the rainfall by years as far back as the records are available, to discover if possible whether any change is taking place in the quantity of precipitation, as it has been claimed by some that forests induce rainfall and that deforestation diminishes it.

I have examined these charts with minuteness, but can find no trace of any effect on the quantities of precitation or on the fluctuations of stream flow that may be regarded as resulting, beyond question, from cutting off our forests. If any such effect has actually been brought about, it is so slight as to escape careful observation. The indications point in an opposite direction.

The charts show that the highest water at Nashville was that of 1882, and that high waters for the past ten years have been noticeably less in height and less in frequency than at the commencement of our records. At Chattanooga the highest water was in 1867. During the past few years, which have been rather "dry" years, the high waters in both the Cumberland and Tennessee have been less in height and duration than usual, which might reasonably be expected owing to the smaller average quantities of precipitation; but it is particularly worthy of note that the low waters were not extreme, but *as a rule were higher than usual*, giving better depths for navigation. Although this may be in the nature of a surprise to some, it is plainly seen on the charts and is well established by reliable records. These facts can certainly be of no use in proving that our floods are higher and our low waters lower than before the forests were attacked. If they prove anything it should be the reverse. It may be stated broadly, and I think with positiveness, that the records of the Cumberland and Tennessee rivers do not indicate that the destruction of forests is having any noticeable effect, deleterious or otherwise, on stream flow or on precipitation.

The number of days and the number of times the river at Nashville has been above 35 ft. or below 5 ft. are shown. In the last decade, 1899-1908, the stage has exceeded 35 ft. but eight times and for 78 days in all; for the previous decade it exceeded this height nine times and for 123 days, and from 1879 to 1888, eleven times and 178 days. This plainly indicates a steady decrease of high-water stages, in both duration and frequency, since 1879. We also find that the river stage was less than 5 ft. for 966 days in the years 1899-1904, an average of 161.0 days per year (in 1905-1908 low water was held up by Dam No. 1); in 1889-1898, 1,538 days, an average of 153.8 days per year; in 1879-1888, 1,418 days, an average of 141.8 days per year, and in 1874-1878, 576 days, an average of 115.2 days per year. By examining these averages we see that since 1878 the number of days the river was below 5 ft., or the duration of moderately low stages, has been increasing; but, on the other hand, in the years 1889-1904 the river reached a stage of less than 1 ft. three times and for an average duration of 20.8 days per year; in the preceding decade the river was below 1 ft. seven times, with an average of 32.0 days per year; and in 1879-1888, nine times, with an average of 32.5 days per year. It thus appears that extreme low-water stages have not been growing either in duration or frequency during the last thirty years. Any statements that low-water conditions are becoming worse on the Cumberland in more rapid ratio than the decrease in the rate of precipitation are untrue, for they are growing better.

The reason for some of this variation seems clear when we examine the record of rainfall. In the last decade the yearly average was 46.089 ins.; in the next preceding, 50.969 ins.; in the next, 56.326 ins.; while from 1871 to 1878 it was 49.47 ins. This rule of change is thus seen to be substantially the same as for the duration of high-water stages, and may account in part for the low-water variations.

In the case of the Tennessee we find from the gage records that the average number of days the river was above 25 ft. was 7.0 from 1899 to 1908; from 1889 to 1898 the yearly average was 9.1; from 1879 to 1888 it was 11.6; and for the four years before 1879 it was 9.3. These averages indicate that for thirty years the *duration* of stages over 25 feet has been steadily declining. Stages of over 35 ft. occurred but four times during the ten years from 1899 to 1908, five times in 1889-1898, and six times in 1879-1888. This shows that the frequency of high water is also growing less. An inspection of the chart will show that the heights are also less of late years, the highest flood having occurred in 1867 and the next highest in 1876. Moreover, we find that from 1899-1908 the river was below 1 ft. only twice (1903, 1904), with an average of 10.3 days per year; from 1889-1898 only three times (1894, 1895, 1897), with an average of 7.7 days per year; whereas, in 1879-1888, it was less than 1 ft. five times with an average of 20.4 days per year. These records demonstrate that low waters have neither been so frequent nor so low of late years. It is therefore not true that the high waters in the Tennessee River are growing higher and the low waters lower, nor is the frequency or duration of these stages increasing as claimed.

The frequency and height of high waters in both of these rivers, as well as the duration of low waters, follow the rule of precipitation closely enough during the periods under observation to force the conclusion that here is the principal cause of the variations in these streams, and that the introduction of forestry as an important factor in either direction is forced and illogical.

It is worthy of note, too, that there has been no falling off in late years in the navigable capacity of the Cumberland River or the Tennessee, due to silting up of channels or any other cause. On the contrary, conditions affecting navigation are distinctly better now than twenty to thirty years ago, even in the portions unregulated. This is largely due, in all probability, to the removal of snags and surface obstructions and the clearing away of overhanging trees. The period of time covered by these observations and the extent of the decrease in forested areas seem ample to show any decided or important change that might be taking place. The records and facts, however, appear to indicate clearly that there is no such intimate or important relation between river stages and forest cover as has been so enthusiastically maintained by the advocates of this theory, nor has the soil wash of the upper regions been raising the beds. No one, I think, desires to detract from the value of forestry as forestry, but it has often been said that the random statements made as to the usefulness of forestry in improving the depth in our navigable streams have unfortunately been much overdrawn, and that the extravagant claims now being urged in this direction have not helped the development of this useful industry. Frequent repetitions may in time create a popular belief in almost anything, but can never alter facts.

The stages which interrupt navigation the most are the extremes of high and low. At either of these, forest cover appears to be of little assistance, or perhaps even a detriment rather than a help. Forest cover of course delays somewhat the run-off of rains, and thus assists materially in promoting absorption by the ground. But these effects are only limited and of small value; the sponge is soon saturated by heavy rains, and floods then occur without hindrance. In dry weather the forests hold back the small rains, permitting them to evaporate more readily, and thus rob the streams of whatever help they might otherwise have obtained. As pointed out by Colonel Chittenden,* it is fortunate that this important industry is not dependent on its relationship to navigable rivers for its usefulness. In their efforts to obtain some constitutional basis for their extensive plans, it is feared that the friends of this valuable department of the Government have imperiled their projects by seeking to furnish reasons for them which are not supported by the facts.

*From Professional Memoirs, Engineer Bureau, U. S. Army, Oct.-Dec., 1909; published at the Engineer School, Washington Barracks, D. C.

†Corps of Engineers, U. S. A., Custom House, Nashville, Tenn.

The Influence of Forests on Climate and on Floods.†

By WILLIS L. MOORE, LL. D., Sc. D.‡

Introduction.

One of the most important problems before the American people to-day is the protection of their natural resources against either the greed of those who would monopolize them for their own individual benefit or those who, while well meaning, would through ignorance destroy our heritage and leave posterity poor.

In the discussion of matters concerned with the conservation of the natural resources of the nation, some of which may involve the expenditure of hundreds of millions of dollars, and the employment for years to come of thousands of public officials, a consideration of the relation of forests to climate, floods, and low water is vitally important.

While much has been written on this subject, but little of it has emanated from meteorologists or from those in the public service who have been actively engaged

[*Trans. Am. Soc. C. E., Vol. LXII. (1909); abstracted in Eng. News, Oct. 29, 1908, in an editorial review; portions of related discussion by Colonel Chittenden also given in same issue.—Ed.]

†Condensed from a report to the U. S. House of Representatives, Committee on Agriculture. The title page bears the following note: When Prof. Moore was before the Committee on Agriculture of the House of Representatives in 1909, to explain the estimates for the Weather Bureau, a discussion arose as to the influence of forests on climate and on the run-off of water. Prof. Moore stated that he was then making some studies on the subject which might lead to some definite conclusions, and he was requested by the chairman of the committee to continue these studies and make a report when they were concluded. This has been done, and the report submitted by Prof. Moore, which follows, is printed by direction of the committee.

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in the forecasting of river stages, both of high and of low water. In the prosecution of such duty these officials have become acquainted with the physical facts involved in the problem and are therefore well fitted to speak on the relation of such facts to stream flow.

The Author Acknowledges a Change of Opinion.

It has frequently been stated that forests control the flow of streams, both in high-water stages and in low-water stages, and that the climate is so materially affected by the cutting away of the forests that droughts have largely increased and that the well-being of future generations is seriously menaced. It is my purpose to present facts and figures that do not support these views, some of which, especially those that pertain to the flow of streams, were held by me up to a few years ago—until a careful study of our own and other records and of the incidents of history caused me to modify my opinions. I shall endeavor not to be dogmatic, but rather to present the reasons for the conclusions that I now entertain, with, so far as may be, statistical and historical evidence to sustain them. And I reserve the right to change or still further modify my views if the presentation of new facts and figures render such a course logical, and do not consider that I shall stultify myself in so doing.

Forests Should Be Protected.

Preservation of the forests, cutting wisely, but never more than they reproduce, enables us to draw from a perpetual supply a certain quantity of material for buildings, for furniture, and for fuel. But of course the *forested land yields not a handful of wheat nor of corn and makes but a wretched substitute for the pasture upon which to feed milch cows and beef cattle.* These conflicting interests, the pleading of the poor man's children for bread and meat and the cry of the country for the lumber that only a woodland can furnish would, if there were no other interests to modify the result, somewhere find an inevitable balance. But just as the body is more important than its raiment, so, too, is its food more important than its shelter; and therefore in every country *the general tendency, with growth of population, is to convert forest lands into cultivated fields, and this tendency should not be discouraged unless it can be shown that deforestation has augmented droughts and floods, and I believe that it can not be so shown; I believe that forests should be preserved for themselves alone, or not at all.*

It is found that in some limited areas where the forest is cleared away, the soil, owing to its nature and slope, will not admit of successful cultivation. It may wash so badly under heavy rains as to become unfit even for reforesting. In others, owing to the nature of the surface, cultivation is impossible. These are fit places for local control, provided such control is commercially feasible, but not for national control, *unless it can be demonstrated that the conditions at these places materially affect the navigability of streams or harmfully affect the climate of the continent at large.*

Effect of Forest on Climate.

It is often said that the climate of a given place depends upon the extent and proximity of wooded areas; that the number of rainy days and the total amount of rainfall are modified by change of forest extent; that the depth of floods, the shallowness of low water, and the regularity of flow are all profoundly modified by changing the proportion of fields to forests in the watershed.

Now, the extent and even the nature of these influences is not a matter, as often is implied, of universal agreement. In regard to change of climate, regardless of the cause, trustworthy records of temperature, of rainfall, and of other meteorological elements do not cover a sufficient range of time to furnish all the data necessary for a *statistical* solution of this problem.

The fact that dead forests stand long after the streams have receded seems to prove that they are the last to disappear rather than the first, and therefore that their removal did not precede the drought but rather that the forests ceased to exist when the rainfall became deficient. Unmistakable evidence is found of the existence of extensive forests in Arizona and New Mexico, where only the petrified trunks of trees now remain. It can not be said that man removed these forests and brought on the drought.

[We omit most of the discussion under this head, both for lack of space and because it seems to be generally agreed, at least among engineers, that forests have but little effect upon climate.—Ed.]

The flooding of an area, the cutting away of forests, erosion, and sanding may have either minute or appreciable effects upon local climates in proportion to the magnitude of the areas affected, *but this does not mean that there is any great difference in the climatic effect between a forest covering and one of bushes, of grass, or of growing crops; and it does not signify that there is sufficient change in the thermal conditions, due to the activities of man, as to make an appreciable difference in the temperature at an altitude of one or two hundred feet, or to affect the general climatic conditions, or to cause storms to be more frequent than formerly or of greater severity, or to increase the amount of precipitation.*

A Plea for Tolerance of Opinion.

But this discussion should not be approached in an intolerant spirit. We have accurate records of climate from only a few isolated places in this country that extend back for a period of as much as one hundred years, and the Government's extensive records only cover a period of forty years. I would warn against hasty conclusions; against accepting as final the deductions of several investigators who have recently publicly discussed the flood records of the Weather Bureau. They find a most alarming increase in the floods of the Ohio Valley and other places, for which I find no justification. Let logic, reason, and investigation have time to operate, for any man may be honestly mistaken and draw general conclusions from inconsequential details or deceive himself by the improper grouping of data.

Records of Precipitation Show No Material Change.

The records of precipitation of the U. S. Weather Bureau do not show that there has been any appreciable permanent decrease in the rainfall of any section of the United States. There are undoubtedly periods covering a number of years of continued deficiency in precipitation for certain districts, but at the same time other districts may show a corresponding increase. [Here follows a 92-year rainfall record at Fall River, Mass., records for a number of stations in portions of Central West, where there are practically no forests, and comparisons of New England and Ohio Valley conditions; we retain a few sentences only of this discussion.—Ed.]

NEW BEDFORD.—The average fall for ten-year periods from 1814 to 1908, inclusive, indicates that while the rainfall during the past few years has been considerably less than the average, it has not been less than has occurred in numerous previous years—notably from 1814 to 1819, from 1833 to 1839, and from 1860 to 1866. Further investigation shows that for the first fifty years of the period the average annual rainfall at that point was about 46 ins., while during the last forty-five years the annual fall has increased to more than 47 ins. *This indicates that instead of a diminishing rainfall we have the evidence that, if there is any variation at all in the precipitation, it is a slight increase for this region.*

GENERAL SUMMARY.—A comparison of the two curves illustrates the fact elsewhere referred to that the rainfall over a region so large as the United States is not by any means uniform in its distribution. Thus the period of relatively light rainfall in New England during 1880-1883 was one of heavy rainfall in the Ohio Valley and elsewhere in the great interior valleys. Likewise in 1878 there was heavy rainfall in New England and light rainfall in the Ohio Valley.

In New England, where deforestation began early in our history and has been extensive, the mean of the fluctuations in the rain curve is a steady rise since 1836 up to a few years ago and in the Ohio Valley, where the forest area has been greatly diminished, there is no decrease of rainfall shown by the average of the fluctuations of the curve. These facts are important and can not be successfully disputed.

The Effect of Forests on Floods.

I have always held to the opinion that the cutting away of forests has had little or no appreciable effect on the amount of precipitation or on the general temperature. But until recent years I did believe that deforestation had an important and beneficial effect on the conservation; that is, on the economical use of the rainfall, and that forests restricted the run-off. But study and investigation have caused me to modify my views.

Professor Abbe says:

The cultivated soil outside the forest, when plowed and broken open down to a depth of 8 ins., acts as a sponge to retain water quite as well as does the ordinary humus of a forest, especially when we consider that under a forest less rain actually enters the humus. In fact, such measurements as have been made show that the amount of water that is eventually given up from the forest humus varies but little from that given up in the course of time by the unforested, cultivated soil. The total run-off from the two regions does not eventually differ greatly, *but it does differ in the speed.* However, it may be neither the amount nor the speed of run-off from the soil that determines the occurrence of river floods. We must distinguish between the soil run-off and the river run-off. When water has once entered the river channel its movements are determined wholly by the force of gravity, the curvature, the section, and the slope of the channel. Floods may occur in every small tributary and yet these waters may so enter the main channel as to produce only a gentle rise throughout its whole length. At other times the smaller elementary floods may conspire and produce a specially disastrous flood in the main channel. Therefore the occurrence of disastrous floods does not depend on rainfall alone or wholly on soil run-off, but equally and principally on the relative times at which floods occur in the individual tributaries, and the time required by them all to reach and combine at any given point in the main channel.

This is a tangled problem, since the result must depend upon the slope of the ground; the nature and condition of the soil; the nature of the forest, whether deciduous or evergreen; the nature of the general climate of the place, whether it has cold, snowy winters or rainy ones, and whether the spring merges gradually and abruptly into summer; upon the use or treatment of the cleared surface; and probably upon other conditions.

The foresters are generally in accord in the belief that the forests exercise a marked restraining influence on floods and a conserving influence on precipitation, even if they do not actually increase it by an appreciable amount, the rainfall. On the other side, army and civilian engineers and meteorologists generally believe that the broken, cultivated, permeable soil, which is covered by the greater portion of each year with millions of the rootlets of growing grasses and cereals, is equally as good a conserver of the rainfall as the forest area itself, even though the latter has the advantage of the deep boring of large roots into the substratum; that the evergreen forests prevent the drifting of the snow and at the same time their heavy foliage protects the snow from the sun and permits a slow melting, which is all absorbed by the forest cover until it is saturated, and then with further heat the water breaks out in a flood; that the function of deciduous forest trees is to catch the falling snow, distribute it equally over the surface, and thus facilitate more rapid melting by causing the snow to present to the warm air a greater melting surface than it does in the open, where wind drifts it into banks in the lee of opposing objects and stores it in depressions and ravines, so that it may remain for a considerable time after the evenly distributed blanket has disappeared from the forests.

It has been shown by Chittenden that in Yellowstone Park and similar mountain regions the forests protect the snow from drifting, melting, and evaporating, while in the open there is much drifting and an early clearing up of those places well exposed to wind and to sunshine; therefore, when warm weather and its rain come on abruptly, and come to stay for the summer, as they do in those regions, the melting of the snow in the forests, because of the greater area exposed, the surface being uniformly covered, is far more rapid than it is in the open where it is badly drifted, and leads to higher freshets and less enduring run-offs. *On the whole it is probable that forests have little to do with the height of floods in main tributaries and principal streams, since they occur only as the result of extensive and heavy rains, after the ground is everywhere saturated, or when heavy warm rains come on the top of deep snows.*

Run-Off and Absorption.

Concerning the surface run-off, it appears to be generally held that when the rainfall is small, the dead leaves, the moss, the tangle of undergrowth, and the like, in the forests may modify or entirely prevent flow, and may slightly intensify low-water conditions of summer, while on the cleared surfaces, except that of freshly-cultivated fields, this is not so markedly the case. When the rains are heavy and continued, there is surface flow in the forests as well as in the open, and the two do not materially differ, for it can be shown that the run-off from a smooth surface and from one covered with sticks, dense grasses, or forest, are equal after the rough surface becomes saturated, and it is long after *all surfaces* have become saturated that flood conditions can occur.

Because of their open, porous condition sandy soils and freshly plowed fields are the best absorbers, and in general forest ground is thought to be more penetrable to moisture than is that of the cleared fields, except when the latter are freshly broken, but the greater part of the cleared land is either broken and cultivated several times during the year or else it is occupied by vegetation that exercises either partly or wholly as great a conserving influence as the forest.

All of these problems could be definitely settled beyond the possibility of argument if we had accurate river gagings from day to day and year to year, together with a full knowledge of the rainfall and of the proportion of the wooded to cleared areas, data that unfortunately we do not have. We must, therefore, reason empirically from the best information at hand, and this insufficiency of data renders less positive the conclusions of all investigators, no matter which side of the question they be on. [Italics ours—Ed.]

Effect of Forests on Floods in France.

An important contribution to this discussion was made in 1873 by Capt. Charles J. Allen, of the Engineer Corps, U. S. Army, in the translation that he made of extracts from the work of M. F. Vallès, which treats of the influence of forests on floods and inundations. This translation contains quotations from the works of M. Belgrand and other French engineers, who had made the hydrology of the basin of the Seine a special study*. Among other things M. Belgrand says†:

*Annales des Ponts et Chaussees, annee 1852, premier semestre, p. 102.

[†We omit all of the quotations from Belgrand except some conclusions and statistics relating to the Seine, which are all the more interesting because the recent (1910) floods in the Seine appear to have exceeded all previous height records and thus tend to vitiate the conclusions.—Ed.]

Now these basins, so remarkably alike, we have; they are those of the Seine in the seventeenth, eighteenth, and nineteenth centuries. Everything in these is alike excepting the extent of the forests, which has steadily decreased, so that if we were in possession of adequate information of some exact measurements of the greatest inundations during the time specified, we could easily test the correctness of our theories.

In fact, observations of this nature have been made; they go back to 1615, about the time when French industry began to develop, and when, consequently, the felling of timber to a great extent commenced.

This places at our disposal an interval of five half centuries.

In a memoir published in 1814 by the engineer Egault, these observations were compiled, discussed, and arranged with reference to the heights of the most marked inundations. We add to the results collated by them those which have been obtained since his time and give them in the following table:

Dates of the inundations.	Height at the bridge of La Tournelle. Ft.	Mean per half century. Ft.
July 11, 1615	29.99	
January, 1649	25.10	27.53
January, 1651	25.59	
March 1, 1658	28.87	26.36
March, 1690	24.61	
March, 1711	24.77	
December 25, 1740	25.92	25.34
January, 1751	21.98	
November, 14, 1764	22.97	
March 4, 1784	21.85	22.42
February 4, 1799	22.87	
January 3, 1802	24.44	
March 3, 1807	21.85	
May, 1836	18.66	21.22
February, 1850	19.91	

The deductions from this table are striking. The continued decrease of the floods for each half century is remarkable. The waters attained a mean height of 27.53 ft. in the first half of the seventeenth century; they only attained a mean of 21.22 ft. in the present. According to this, we have experienced an amelioration of nearly 6.56 ft., and yet the trees have been steadily and unceasingly cut down, and the forests transformed into cultivated farms.

What would we gain, then, to-day, I ask, in rewooding our fields? It would be but an unfortunate attempt to restore the old order of things, when the floods of the Seine rose to 29.53 ft. above the low stage.

In connection with the conclusions reached in this report, as well as with regard to those reached by the foresters and others who differ from my views, I would emphasize the fact that none of us have flood data extending over any great period of time, but in Europe we fortunately have some long-period observations. The preceding pages show the result of observations made by competent engineers during two and one-half centuries in the basin of the Seine, and show that there has been a gradual and constant decrease in the height of floods with the diminution of forests.—[See our foot note—but we do not mean to assert that the recent Seine floods were unquestionably due to deforestration.—Ed.]

It is therefore apparent [preceding argument omitted—Ed.] that the precipitation that causes floods in the eastern half of the United States is from the aqueous vapor that is raised up from the vast waters to the south and southeast of our continent, and that *the supply is inexhaustible. Our rainfall, then, is the result of such fundamentally great causes as not to be appreciably affected by the planting or cutting away of forests, or by any of the operations of man in changing the character of the surface covering of the continent*, although to statistically and positively settle the question beyond the possibility of argument it would be necessary to have scientific data of temperature, rainfall, and the height of rivers, beginning at the first settlement of the continent and continuing through to the present time. Such records, of course, are not in existence. But the fundamental fact that the precipitation of the United States is due to the great hemispherical circulation of the air, and to the relation of the great bodies of water to land, and the direction of the vaporous-bearing currents, and the trend of mountain systems is something that can be positively shown.

Erosion.

Another effect of deforestation, that of erosion, is of importance, but of unequal importance in different sections. In level countries it makes but little difference in this particular whether the ground is waste, cultivated, or densely forested, while in hilly or mountainous sections the result is different. When the soil becomes well sodded with grass, erosion is little worse in fields than in the woods, but usually the fields are cultivated from time to time, and occasions come when the best of care and cultivation can not prevent the formation of bad gullies that injure both the gullied fields and those of the lower grounds that are overflowed.

Ratio of the Forested Area, or Mountain Watersheds, to the Total Watershed.

I am of the opinion that not enough consideration has been given to the relative magnitude of the areas involved in the creation of floods. A flood in any given stream is usually caused by the precipitation over its entire watershed or over those of the major tributaries and is affected but comparatively little in a region like that of the Ohio basin by the precipitation over the extreme upper reaches, usually the forested area, or any other area that could be reforested without seriously encroaching upon the rich alluvial plains.

A critical examination of Chart C [not reproduced—Ed.], which shows the entire river system of the Ohio basin and gives the exact limits of its boundaries, and which also indicates the elevations, shows what a comparatively small area in relation to the total catchment basin lies at elevations of more than 1,000 or 1,500 ft. above sea level. This chart furnishes a conclusive answer to those who believe that floods, except, of course, torrents in the mountain creeks, are caused by the precipitation on the comparatively small area of the watersheds at the headwaters of rivers. If it be granted that forests control the flow of streams, and I doubt that they do except as stated above, it will be necessary, in order to have an appreciable effect on navigable or other important rivers, to reforest areas many times in excess of anything that so far have been contemplated. The *rugged mountain slopes and tops, where land has little value, are unimportant as flood producers. It will be necessary actually to reforest the lower slopes and valleys where the land is of great value and where it should be devoted to agricultural purposes.* I can not escape this conclusion.

Are Floods Increasing?

Two papers have recently appeared, in both of which the argument is made that there is a marked tendency toward increasing flood frequency as a result of deforestation. The first of these papers in point of time was that of Mr. M. O. Leighton, Chief Hydrographer United States Geological Survey*. The second paper appeared in volume 2, Senate Document No. 676, beginning at page 112, and later as Forest Service Circular No. 176, January 11, 1910, under the signatures of Mr. William L. Hall, Assistant Forester, and Mr. Hu Maxwell, expert.

Before entering upon a discussion of these papers I wish to draw attention to the following statement in the last-named paper, page 3:

> * * * Both the Geological Survey and the Forest Service *have secured data*†, and the results warrant the statement that unmistakably floods are steadily on the increase in some of our most important rivers.

I wish to remark in connection with this statement that substantially all of the data used by the authors of the papers above mentioned were drawn from the records of the U. S. Weather Bureau‡.

In Water-Supply Paper No. 234 the author has made a diagrammatic arrangement of data composed of annual and decennial means, whereby he shows an apparent progressive increase in the number of flood days at Wheeling, W. Va., and other points, without a proportionate increase in the amount of precipitation. It appears to me that his argument is defective in at least two particulars.

(1) The flood or danger stage of the rivers at the various places discussed by him was long ago fixed by the Weather Bureau as being at the point where the river either overflows its banks or damages property adjacent thereto. Mr. Leighton has disregarded these points and arbitrarily assumed, for the purpose of his discussion, a considerably lower stage in each case, so that his argument fails completely so far as it relates to flood frequency; for example, at Wheeling, W. Va., he assumes a stage of 20 ft., whereas the Ohio at that point is not in flood until a stage of 36 ft. is reached. What the author is discussing is therefore not floods as such, but moderate stages of the river.

What appears to me to be a second defect in the author's argument lies in his acceptance of the total number of so-called flood days (20 ft. or more being a day of flood) divided by the annual precipitation as an indication of flood intensity, since the annual rainfall, as he himself acknowledges,§ bears little or no relation to floods. Greater floods may occur during a year of deficient precipitation than during one of excessive annual precipitation if the proper proportion of the rainfall be concentrated over a limited area in a limited time.

An examination of the data for Chattanooga, Tenn., given by that author, discloses the fact that there has not been any increase in the number of so-called flood days at that place. The average amount of precipitation for each daily river stage of 20 ft. or more, as determined by him, is almost exactly the same for the two periods, 1884 to 1895 and 1896 to 1907, inclusive. But in the number of *actual flood days*, as determined by Professor Frankenfield, the official in charge of the Weather Bureau river and flood service, that is, 33 ft. or over (and the river does not reach the danger or flood stage until it stands 33 ft. above low water), there was a considerable decrease in the second period, in harmony with the precipitation.

I understand that when Mr. Leighton speaks of "the ratio of the annual number of days of flood to annual precipitation," he means the number of days (stage above 20 ft.) in each year divided by the *total* precipitation for the year. Thus, if the number of flood days in any one year is 20, and the total precipitation is 40 ins., the ratio would be 20 divided by 40, or 0.5. These ratios are totaled in eleven-year periods and the average of each period obtained. The average for the first eleven years, as obtained by him, was 0.38, and of the second, 0.48, indicating, in his opinion, an increase in flood intensity during the second eleven-year period, as 1 in. of rain made only 0.38 of a flood during the first period, while in the second period 1 in. of rain made 0.48 of a flood. In other words, during the first eleven-year period 1 in. of rain made only 38% of 20 ft. of water, or 7.6 ft.; while during the second period 1 in. of rain made 48% of 20 ft. of water, or 9.6 ft.

This line of reasoning leads to wrong conclusions, as it is certain that the ratios obtained by dividing the number of days that a certain gage reading was reached or maintained by the annual, or for that matter by any other, precipitation, without entering into the problem the exact height of water gives a meaningless result. It appears to me to be a fatal method of reasoning to take simply the number of days that a stage of 20 ft. was reached, without regard to heights above 20 ft. Therefore, if on a certain number of days the gage reading was exactly 20 ft., one would get precisely the same quotient as he would if on the same number of days the gage readings were largely in excess of 20 ft.

I now come to that part of the discussion in Water-Supply Paper No. 234, which has been widely quoted by the adherents of the forest-control idea, viz., the proposition that, although the flood periods in the Tennessee have decreased in later years due to diminished precipitation, the flood tendencies have increased. I quote as follows from page 23:

> The results for the Tennessee basin cover 24 years, from 1884 to 1907, inclusive. . . . Summing up the flood-producing rains for the 24-year period, it is found that the total is 335, of which 313 occurred from December to May, inclusive, and the remaining 22 during the other portion of the year. It is apparent that the number of such rains from June to November is not sufficient to afford a basis of comparison. Therefore only the December to May floods will be considered. . . . On dividing the period covered by these 313 floods equally, two consecutive twelve-year periods are afforded, which give a basis of comparison. The floods in the later period, resulting from a given depth of storm precipitation, are clearly shown to be more severe than in the earlier period. The method of presentation further makes its possible to compute the increase in flood tendency due to deforestation in the Tennessee.
>
> . . . . . .
>
> If we now divide the number of flood days by the number of storms the result will be the number of days per storm.

DAYS OF FLOOD PER STORM.

Period.	Storms in inches precipitated. 1 to 1.5.	1.5 to 2.	2 to 2.5.	2.5 to 3.	3 to 3.5.	3.5 to 4.	4 to 4.5.	4.5 to 5.
1884-1895	0.7	0.5	2.5	1.8	2.6	5	6	8.1
1896-1907	.4	.9	2.6	2.7	3.2	6	8	6.7
Percentage increase	−43	80	4	50	22	20	33	−17

The algebraic sum of the above percentages is 149 and the average is 18.75, which sums up the effects of deforestation on run-off from 1884 to 1907, inclusive.

I invite attention to the figures given in this table "Days of flood per storm." If the run-off in the second period was greater than in the first, due to deforestation, would not the latter show a uniform and progressive influence increasing as the amount of rainfall increased? How, then, does it happen that a decrease in run-off of 43% is shown for rains of intensity 1 in. to 1.5 ins., while in the next higher grade of intensity, viz., 1.5 to 2 ins., an increase of 80% is shown? In the next higher grade, viz, 2 to 2.5 ins., the increase drops to 4%. These results founded, in my judgment, on incorrect premises, are both inconsistent and meaningless. To "divide the number of flood days by the number of storms" gives no valuable quotient, for the gage readings selected as floods are not floods, but only moderate stages, and no account is taken of the actual height of the water, and while the conclusion is reached that there is an increase in flood intensity of 18.75% in the Tennessee basin in the past twelve years due to deforestation, no records or other evidence are presented that there is not as much forest area in this basin as there was twelve years ago; or that, if there is a decrease, it would be sufficient to account for such a large increase in flood intensity.

But—and here is the most important matter in the consideration of Mr. Leighton's conclusions—no matter how complete the data may be, or how fundamentally sound and fair its collation and grouping, the comparison, the one with the other, of such short periods as those measured by only twelve years, can not give results with regard to changes in climate and floods that will permit the most skilled meteorologist or engineer to draw fundamental conclusions that can have

*Report of National Conservation Commission, p. 95, and Water-Supply Paper No. 234.

†The italics are mine. (Author.)

‡In Water-Supply Paper No. 234 the impression seems to be given that the author's researches and conclusions are based on a consideration of river discharge measurements. It is proper to state that river discharge measurements were begun under the direction of the U. S. Geological Survey in 1896 and that gage readings of heights of rivers were begun by the United States Signal Service, now Weather Bureau, in 1874.

§Page 22, Water-Supply Paper No. 234.

any value. Precisely the same amount of rain falling in the two periods and no change whatever in forest or cultivated area might produce largely differing results on floods, depending on the sequence with which it fell over the different tributaries and how it was concentrated or scattered, and on many other complicated conditions of run-off, such as the coinciding of the flood volume from one tributary with that of another, instead of each passing down the main stream at different times.

There is also the difficulty of securing accurate precipitation data. Whenever the height of the gage is altered or other change made in its environment that disturbs the flow of the air currents the readings of one period may not fairly be compared the one with the other. These defects vitiate the precipitation data of many stations of the Weather Bureau, especially those in large and growing cities, and can only be remedied by the Government controlling for a long period of years an area at each station so large that it can determine the exposure and keep it constant.

Rainfall and run-off of the Ohio Basin.—We have no direct method of measuring the run-off, but we can reach a fair approximation to it by a comparison of the rainfall and river data for any given watershed. If, for example, the surface conditions over any considerable part of a watershed have been materially changed by deforestation or other means, and if, as claimed, such change operates to increase the run-off, then the flow of water in the streams after the change has been brought about should be greater for equal depth of precipitation. This method is a rough one, to be sure, but it appears to be the only one permitted by the records as they exist.

Cincinnati, Ohio, has been chosen as the point whose river observations are best adapted to our purpose, although some objection to that place lies in the constriction of the natural river channel caused by the encroachment on the banks of the stream by various artificial structures. The station at Pittsburg, Pa., is better situated for comparative purposes, but the low-water stages at that place of late years have been vitiated by the construction of the Davis Island dam. The construction of dams at several places in other rivers has lowered the value of low river gage readings for comparative purposes.

In the tables [detailed tables omitted.—Ed.] which follow I have given the actual mean monthly stage of the Ohio at Cincinnati for every month of the period 1871 to 1908. The average of these monthly means has been computed for the first period of 19 years; these averages have been summed up for the twelve months of the year, and that sum has been divided by twelve in order to get the annual mean. The number so obtained, 17.3 ft., is therefore the average stage of the river for the entire 19 years, as computed from all of the daily stages for that period. In like amnner the average stage of the river for the second period of years has been computed.

The average precipitation for the watershed has not been so easily obtained. Only in exceptional cases are continuous measurements of precipitation available for comparative studies. The government records in large cities are of necessity made from gages whose immediate environment has been changed repeatedly in the course of a long series of years, and it was for this reason that the rain-gage records from Cincinnati and Pittsburg were ignored. The points selected—viz., North Lewisburg and Portsmouth, Ohio, and Confluence and Franklin, Pa.—are the best and practically the only long-period records available in this watershed. A better distribution throughout the watershed would have been preferred, but it is not possible to obtain it. The precipitation, like the river stages, has been computed in periods of 19 years each.

Summarizing, we have:

Average stage of the Ohio River at Cincinnati, Ohio:	Ft.
1871 to 1889	17.3
1890 to 1908	17.5
Average precipitation in the Ohio watershed, as determined from the stations above named:	Ins.
1871 to 1889	41.3
1890 to 1908	41.8

I consider that the results secured from the discussion of the precipitation and the gage readings in the Ohio basin, as given in the foregoing tables, form one of the most important contributions made by this paper. Here we have avoided the using of indefinite and meaningless data, and have taken the longest period of time for which accurate records can be secured on a watershed that is suitable for this line of inquiry. We have not simply counted the number of days that the river stood above some arbitrarily selected stage without taking into consideration the exact height of the river. Neither have we divided the gage readings by some arbitrarily selected portion of precipitation data. On the contrary, we have endeavored to profit by the errors of previous investigations, and to lay the foundation of an inquiry that would mean something when we reached the end of our computations. For this reason we have selected a typical station on the main stream that drains the Ohio Basin and have discussed rainfall data that are the most accurate of any in the region, having been subject to less errors due to varying environments. Any deductions made from an inquiry founded with less care, or from data of a less degree of accuracy, must bring results from which it would be unsafe to form definite conclusions.

Now let us see what is the result. The average stage of the river for the first 19 years is 17.3 ft., and for the last 19 years 17.5 ft., showing that there is practically no change in the run-off of the Ohio Basin between the first period and the last. When we examine the average precipitation over the watershed that is drained by this river we find that for the first 19 years it was 41.3 ins., and for the last 19-year period it was 41.8 ins., a slight increase in precipitation for the latter period that agrees precisely with the slightly greater average flow of water. There is a perfect agreement here between the precipitation and the flow of the stream. I do not know what has been the area deforested in this valley during the 38 years under discussion, but whatever it is it seems to be apparent that such altering of the relation of forest area to cultivated area has had no appreciable effect on the flow of the Ohio River. I am aware of the fact that by the studying of short periods of data on small tributary streams, and especially by the grouping of data dissimilar from what is employed in this discussion, all manner of results may be shown.

I believe that the reader will acknowledge that I have shown in the several preceding paragraphs that the average discharge of the Ohio River, where I presume deforestation has been as great as in any other part of the country during recent time, has not changed for a period of 38 years, except as caused by precipitation. It will now be interesting to know how the two periods compare with regard to extremely high water and extremely low water, and this will be discussed in the coming pages.

High Water and Low Water on the Rivers of the Ohio Basin.—I had Prof. H. C. Frankenfield, Chief of the River and Flood Division of the Weather Bureau, compile the data from one station on the Cumberland, three on the Tennessee, and five on the Ohio, and establish the average high water for the four wet months, January to April, and the average low water for the four dry months, July to October. He then took the departure from the normal, both for the precipitation and for the height of the rivers, and found that *the average high water was no higher and the average low water was no lower for the last half of the period than for the first half.* The differences were so slight as to be inappreciable, but what changes occurred were in favor of the low water being slightly higher and the flood waters slightly less. There were variations in the periods and intensities of floods that bear a direct and proper relation to the precipitation. In making his report, Professor Frankenfield points to the fact that the low-water stages at Pittsburg, Pa., and Nashville, Tenn., are not fairly comparable with those of the other stations on account of permanent pool stages caused by dams operated during the low-water season for purposes of navigation. The first dam below Pittsburg was placed in operation in 1885, and that at Nashville in 1904. The effect of these dams is to furnish higher low-water stages than would result without them. The effect upon the normal low-water stage at Nashville was not marked, but at Pittsburg it is perceptible. However, in his conclusions he did not make allowance for the slightly higher low-water stages at Pittsburg on account of the dam, but when included with the other stages of the river this defect probably is not apparent.

According to our line of reasoning, which we believe to be fair and conservative, it is shown that the average discharge of the Ohio River is not greater as the result of deforestation during the last 19 years than during the preceding like period, and that the average high water in the rivers of the entire basin, which includes the Tennessee, the Cumberland, and the Ohio, is not higher and the low water is not lower.

Are real flood stages more numerous than formerly?—The next line of inquiry will be for the purpose of determining whether or not there has been in recent time an increase in the number of days that these rivers were at or above the flood stage, and in making this inquiry *exact flood stages* will be used, not simply gage readings less than flood. Again I called on Professor Frankenfield to prepare the necessary data. As the data were not complete with regard to flood stages for the first ten years of the period that we have been discussing, he took a period of ten years less in length, beginning with 1879 [detailed table omitted.—Ed.]

In the first 14 years [1879 to 1893] there were 2,073 days that the Cumberland River at Nashville; the Ohio at Pittsburg, Cincinnati, Louisville, Evansville and Cairo; the Tennessee at Chattanooga, Florence and Johnsonville, were at the flood stage—that is, they were bank full or overflowing. During the last 14 years [1894 to 1908] the number of such days is 1,370, an excess in the first 14 years of 703 days, or an average of 46.9 days excess per year in the first period over the second.

Now, I would guard against unsafe conclusions from these results. The fact is that abnormally heavy precipitation for several years in the forepart of the first 14-year period, especially that which caused the famous 1882 flood, places such a preponderance of flood days the first period that it would be unfair to claim that the has been any such permanent decrease in flood intensi as is shown by this table. It is given for what it worth, and further to emphasize the fact that conclusio on which fundamental theories or policies are bas should not be founded upon short-period data. While am strongly of the opinion that there is no permane increase in the number of flood days for the rivers the United States as a whole, between the last 50 yea and the preceding 50 years, I should not rely upon su short-period data as is contained in this table to susta my belief. But if these data of 28 years, which show such a marked decrease in flood intensity of the rivers the Ohio Valley, and which are founded upon unques tionably accurate data, are not sufficient evidence for scientific man to claim statistical proof of the decrease floods, what shall one say of the statements made b Messrs. Hall and Maxwell of the Forest Service, in Vol 2, Senate Document No 676, in a paper on "Surfac Conditions and Stream Flow," which begins at page 112, as follows:

The Tendency is Toward Increased Floods.

On the Potomac River, for which measurements are given for 18 years, the number of floods during the first half of the period was 19, during the second half, 26; while the number of days of flood in the first half was 33, and in the second half, 57.

On the Monongahela River measurements are given for 22 years. During the first half of the period there were 30 floods; during the second half, 52. The number of days of flood during the first half of the period was 55; during the second half, 100.

On the Ohio River measurements are given for 26 years. During the first half of the period there were 46 floods; during the second half, 59. The number of days of flood during the first half was 143; during the second half, 188.

On the Cumberland River measurements were given for 18 years. During the first half of the period there were 32 floods; during the second half, 43. The number of days of flood during the first half was 89; during the second half, 102.

On the Wateree River measurements have gone on for 16 years. In the first half of the period the number of floods was 46; in the second half, 70. The number of days of flood in the first half of the period was 147; in the last half, 187.

On the Savannah River measurements have continued for 18 years. During the first half of the period the number of floods was 47; during the second half, 58. The number of days of flood during the first period was 116; during the second half, 170.

On the Allegheny River measurements are given for 34 years. During the first half of the period there were 39 floods, during the second half, 53. The number of days of flood during the first half was 92; during the second half, 131.

On the Tennessee River measurements have been taken for 34 years. During the first half of the period there were 32 floods; during the second half, 33. The number of days of flood during the first half was 173; during the second half (in this case there was a falling-off), 137.

The conclusions arrived at by the authors are, in my judgment faulty, because:

(1) The shortness of the period of observations at the majority of the stations discussed.

(2) The arbitrary assumption as flood stages of certain heights of water much below that necessary to cause a flood.

As to the period of observations: Those of us who are accustomed to the computation of normals or mean values have always realized how little value they possess unless obtained from data covering a long period of years. This is true of temperature normals, which vary but little from year to year. How much more must it be true of precipitation and river-stage data, with their wide extremes and irregular fluctuations? As a matter of fact any average of river conditions, or any mean annual precipitation determined from ten to fifteen years' observations, would be of little or no value in a discussion of this character, and when two of these short-period normals are compared with each other the actual errors would probably be multiplied.

Second, opinions may differ, of course, as to what constitutes a flood, but the Weather Bureau (and engineers generally) have uniformly defined a river to be in flood when it reached a stage above which damage would be caused, practically the bank-full stage. This being so, it would appear reasonable and proper that this definition of the term should be accepted and data discussed accordingly. If the flood stage at a given point is 18 ft., an assumption of a lower or a higher figure for purposes of investigating the frequency of floods must necessarily be misleading.

I will now take up the rivers in the order named in the quotation and give the net result of Professor Frankenfield's inquiry as to the number of *real* floods:

Potomac.—On the Potomac River the number of floods has not increased, but there were more days of a 12-ft. stage in the last period than in the first. The explanation of this increase is found in the precipitation.

Monongahela.—On the Monongahela River, using data for Lock No. 4, Pennsylvania, 40 miles above Pittsburg, there were two more floods in the second period as compared with the first, the figures being 13 and 11, respectively. Two of the days of flood occurred in March, 1907, as a result of abnormal weather conditions over the watershed.

Ohio at Wheeling.—There was an increase in the num-

ber of floods at Wheeling, but said increase is not shown farther down the river than Parkersburg. It (the increase) disappeared below the mouth of the Great Kanawha, as indicated by the Cincinnati records. The reason ascribed for this increase in flood frequency is an increase in short-period heavy rains. The same conditions appear to have obtained in the Allegheny at Freeport.

Cumberland.—There has been no increase in flood conditions in the Cumberland.

Wateree.—There was a marked increase in the number of flood days on this river during the second period. On the other hand, the precipitation in the watershed shows a like marked increase.

Savannah.—The record for the Savannah River at Augusta shows a marked decrease in the second period as compared with the first.

Allegheny at Freeport.—See Wheeling.

Tennessee.—See detailed discussion on this river in another part of this paper.

Conclusions.

(1) Any marked climatic changes that may have taken place are of wide extent and not local, are appreciable only when measured in geologic periods, and evidence is strong that the cutting away of the forests has had nothing to do with the creating or the augmenting of droughts in any part of the world.

(2) Precipitation controls forestation, but forestation has little or no effect upon precipitation.

(3) Any local modification of temperature and humidity caused by the presence or absence of forest covering, the buildings of villages and cities, etc., could not extend upward more than a few hundred feet, and in this stratum of air saturation rarely occurs, even during rainfall, whereas precipitation is the result of conditions that exist at such altitudes as not to be controlled or affected by the small thermal irregularities of the surface air.

(4) During the period of accurate observations, the amount of precipitation has not increased or decreased to an extent worthy of consideration.

(5) Floods are caused by excessive precipitation, and the source of the precipitation over the central and eastern portions of the United States is the vapor borne by the warm southerly winds from the Gulf of Mexico and the adjacent ocean into the interior of the country, but little from the Pacific Ocean crossing the Rocky Mountains.

(6) Compared with the total area of a given watershed, that of the headwaters is usually small and, except locally in mountain streams, their run-off would not be sufficient to cause floods, even if deforestation allowed a greater and quicker run-off. Granting for the sake of argument that deforestation might be responsible for general floods over a watershed, it would be necessary, in order to prevent them, to reforest the lower levels with their vastly greater areas, an impossibility unless valuable agricultural lands are to be abandoned as food-producing areas.

(7) The run-off of our rivers is not materially affected by any other factor than the precipitation.

(8) The high waters are not higher, and the low waters are not lower than formerly. In fact, there appears to be a tendency in late years toward a slightly better low-water flow in summer.

(9) Floods are not of greater frequency and longer duration than formerly.

A Report on the Chicago Harbor Problem.

In 1908, the city council of Chicago provided for the appointment of a special commission to report on the harbor plan problem, with suggestions as to means for its solution. The report of this commission was reviewed in our issue of April 29, 1909. Following the presentation of this report, the Western Society of Engineers (Chicago) appointed a committee "to confer with committees of the city council and others in regard to the work that is now being planned for the development of the Chicago harbor." This committee is composed of the following members: A. Bement (Chairman), W. L. Abbott, L. E. Ritter, E. C. Shankland and Willard A. Smith. It presented a report at the meeting of the Society on Feb. 16, endorsing the recommendations of the Harbor Commission, and an abstract of the principal features of its report is presented herewith.

The freight tonnage handled at some of the lake ports, including the Chicago and Calumet rivers separately as well as the port of Chicago as a whole, is shown in the accompanying diagram. It appears that water transportation at the port of Chicago was developed on a large scale before business at these other ports had become of much importance, and increased at a rapid rate until 1890, when its real decline began.

There are two reasons why Chicago shipping has declined: (1) A natural shifting and change of business, which could not be prevented; (2) artificial obstructions to navigation, which have made it both difficult and uneconomical for shipping to do business in the river. The advent of large ships in lake commerce and the beginning of the decline in volume of business in the Chicago River occurred at the same time. For reasons of economy large ships were built and they naturally, on account of lower operating costs, took business away from the smaller craft. But as the large ships could not enter the river on account of narrow openings at the center pier bridges, shallow water (especially at the old LaSalle, Washington and Van Buren St. tunnels), and narrow and crooked channels, they necessarily went to other ports for business. It is impossible to determine what proportion of the loss is due to natural, and what to artificial causes. The present problem is in the Chicago River, where facilities of every description for the proper and economical handling of business are inadequate and are such as to make further growth under the circumstances an impossibility. Other transportation features are involved than those of freight and passenger movements upon the river. The problems of cartage by wagon, the handling at railway freight houses, the transfer between railways and the movement through the tubes of the Illinois Tunnel Co., are all interrelated with the river business so that the

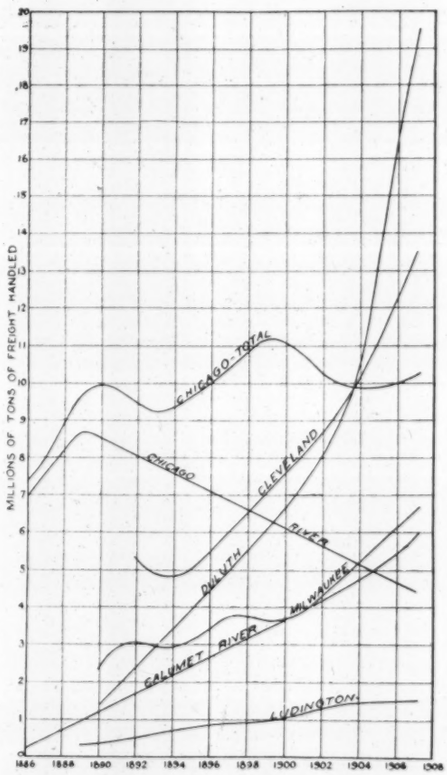

Diagram Showing the Volume of Commerce at Some of the Principal Ports on the Great Lakes from 1886 to Date.

whole aggregation becomes a single problem of considerable magnitude. It appears there must be one general solution instead of several individual remedies.

It is necessary and desirable that the movement of craft that require the opening of bridges be reduced to a minimum. This requirement may be met by freight lighterage on the river and by outer harbor facilities for passengers and freight, making it unnecessary for ships to enter the river with cargo which may be received and distributed by lighters, by the tunnels, or directly to railway cars, which would be moved on car floats or tracks. This would keep at least all package-freight and passenger steamers out of the river. Thus it would be possible to have a large increase of coarse-freight steamers in the river without it being necessary to open bridges any oftener than at present.

There is an enormous volume of miscellaneous freight, which is teamed about the city at a high cost, causing congestion of traffic in the streets and resulting in much inconvenience. A large portion of such goods could be handled by lighters on the river, which would then become one of the city's highways. These lighters would pass under the bridges and therefore would in no way interfere with traffic across them. Under present conditions, steamers carrying miscellaneous freight must pick up and discharge their cargoes at various docks along the river, which results in delay, inconvenience, large cost for service of tugs and frequent opening of bridges. All this trouble and extra expense would be eliminated by a proper lighterage service.

These facts (as set forth in the report of the Harbor Commission) appear to be fully realized, and there also seems to be a general feeling that the city should take some step toward the establishment of such facilities. But the legal limit to bond issues makes it impossible for the city to raise money for the purpose and there appears to be no immediate prospect of its being able to do so. Two schemes, however, have been proposed, which contemplate doing for the city what the city is unable to do for itself.

The Pugh Terminal Co., conducting a warehouse business on the north pier, desires to establish an outer harbor on the lake front, just north of the river mouth. It has a grant from the state of Illinois, and the Federal Government has stated that its plans do not interfere with navigation. While it appears probable that it has sufficient authority to enable it to proceed with its plans, the company seeks a franchise from the city. This scheme contemplates three long piers, one each for incoming and outgoing freight, the third for fruit and passenger business. The freight piers are to be equipped with railway tracks so that cars may run their full length. A refrigerating plant would be provided for fruit and other storage rooms. Adjacent to these docks a system of large warehouses would be built.

A system of lighters would be established for the transport of freight and of railway cars. The car floats would each be large enough to transport from 12 to 16 cars, and would have a movable deck, which could be depressed sufficiently to allow the tops of the cars to pass under bridges. The lighters would be propelled by internal combustion engines, so there would be no smoke nuisance. At convenient points on the river, freight stations would be provided for the receipt and distribution of freight. These would also be connected with the tubes of the Illinois Tunnel Co. Thus the scheme would embrace a very complete system of freight handling and storage. One of the benefits of a service such as this, which is probably not fully realized, is the removal of teams and wagons from the congested streets.

The second suggested scheme for harbor development is that the Sanitary District take over the harbor management and carry out plans necessary for improvement, as the Sanitary District has power to raise money, which the city lacks. A bill giving the necessary authority is before the state legislature. At the time this bill was introduced another was presented, which originated in the council committee on harbor, wharves and bridges; this proposes to give the city the right to build and operate docks, wharves, lighters, etc. In asking these privileges the committee felt that, if granted, it would have a freer hand in dealing with the general harbor proposition, even if funds are not now available.

The ideal scheme would be to center on the Chicago River the business which could be handled by lighters, and the coarse and large cargo freight at South Chicago. But there is considerable of the latter business on the Chicago River, such as lumber, grain and coal, and more is to be had if the center pier bridges are removed. If it is to be had at all, it must be accommodated on the river, because it is needed either for consumption or reshipment at this point and not at South Chicago. Another phase of this matter is that ships select cargo to a port which can furnish return freight. While it is very desirable to develop a lighterage service to its maximum posibilities, it is not good business policy to drive away desirable traffic which must be carried by ships that are required to enter the river. Yet it is desirable to reduce to a minimum the necessity for ships entering the river and to this end it may be feasible to handle a portion of the grain traffic in cars by lighters direct from rails to ship, in an outer harbor, as well as through storage elevators located at an outer harbor.

While under present conditions the Chicago River is the center of the high class package business, and the Calumet that of coarse freight, conditions will change at the latter, for the Calumet locality is growing rapidly. In a few years the Calumet River will find itself confronted with just such conditions as the Chicago River, and it is essential that the mistakes here be not repeated at South Chicago. In this connection, it is well to realize that Chicago will soon have two congested centers, one on the Chicago River, the other at the Calumet River. The public is, no doubt, disposed to feel regarding the Calumet as did the people here 25 and 30 years ago (that the river would take care of itself), but if development there is not properly cared for, there will be a repetition of the errors that have cost so much at the Chicago River.

The committee is strongly of opinion that the outer harbor facilities should be developed and utilized to the maximum, to so far as practicable keep large shipping out of the rivers, and this applies to the Calumet as well as the Chicago River. It does not, however, favor the exclusion of necessary traffic therefrom, which cannot otherwise be accommodated. Considering the great value

and convenience of outer harbor facilities, it is felt that ample reservation should be made on the water front for any possible future requirements, and if this would interfere with the schemes for park development such plans should be changed to meet harbor requirements.

That the replacement of bridges and the straightening and widening of the channel of the river should be done by the city is without question. But the municipal operation of docks and lighterage service, in the opinion of the committee, would not be in accordance with good policy. It is not certain that it would be necessary or desirable for the municipality to construct and own docks, to be leased to others, if private enterprise could be depended upon to do so, but, it would be necessary for the city to exercise proper control over such harbor facilities as would be developed by such private enterprise.

An Instrument for Measuring and Recording Tunnel Sections.

In tunnel construction work, and especially in rock tunnels, it is necessary to measure the cross section of the excavation at frequent intervals in order to see that it conforms to the prescribed limits, and to show any excessive variation from the limits. In completed tunnels measurements are also taken as a rule to ensure that the desired section is obtained, and in old tunnels measurements are taken sometimes to ascertain the exact clearance and to detect any signs of bulging or collapse. For such work measuring instruments of different kinds are used, and some of these have been described in our columns. In nearly all these instruments, however, the principle consists in setting a fixed point (adjusted in the tunnel axis) and measuring the distance from this to the side of the excavation at various positions or angles. The measurements have then to be plotted in the form of a cross section.

A new cross-sectioning instrument which has been in use for some time in Chicago has the special feature of automatically plotting the cross section upon a reduced scale. It was designed for the purpose of recording cross sections of tunnels in course of construction, and also for showing any deformation in completed tunnels due to faulty construction, exterior pressures, or other causes. It was designed by Mr. Geo. F. Samuel, Assistant Engineer in the Department of Public Works, Chicago, and was first used in the construction of the land portion of the new Southwest water tunnel, which was described in our issue of Nov. 14, 1907. The instrument was made by Mr. Peter Heer, of Chicago.

The instrument consists of an arm which passes through a gear box fitted with a pencil that traces a diagram of the tunnel to scale. One end of the arm is fitted with a wheel, and this is held in contact with the tunnel wall as the arm is moved around the cross section. The instrument is mounted on a circular wooden target 20 ins. diameter and 3 ins. thick. This target is supported on a horizontal bar with extensible ends; this is placed on the springing line of the tunnel, at right angles with the tunnel axis, and clamped in place. The bar is supported by two legs that are placed off the center line of the tunnel, so that cars used for handling material can pass freely while the instrument is in use.

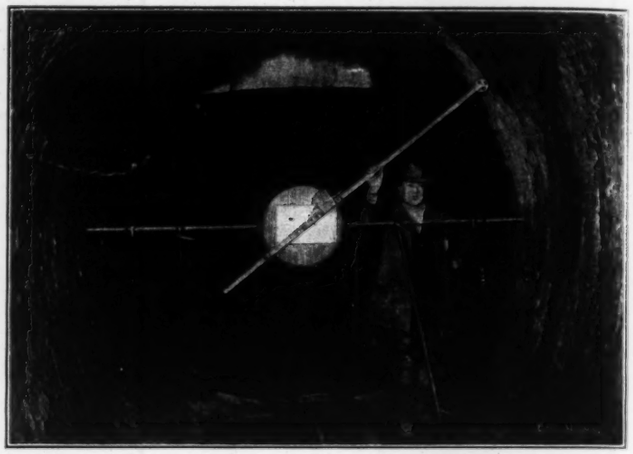

FIG. 1. TUNNEL CROSS-SECTIONING INSTRUMENT IN POSITION FOR USE IN A COMPLETED TUNNEL.

Attached to the target in such a manner as to allow it to revolve through 360° is a hollow brass rod 24 ins. long and 1 sq. in. in section. The box containing the reducing gear and pencil holder is attached to this hollow rod, while the measuring arm (with a trolley wheel at one end) passes through it, so that the arm and pencil holder both move through the same angle. That part of the arm which passes through the gear box is fitted with a rack engaging with one of the gear wheels, while the gear wheel at the other end of the train actuates the pencil holder, which moves in the same direction as the arm. The gear train is made with a ratio of 1 to 24, giving a diagram to a scale of ½-in. to the foot. For a 12-ft. tunnel the diagram is 6 ins. diameter. This scale is found to be satisfactory for inspection and for use with the planimeter in computing the area of the cross section of the excavation and lining of the tunnel.

Fig. 1 shows the instrument in operation, and Fig. 2 shows the manner of attaching the instrument to the target. Fig. 3 shows an enlarged view of the instrument with the diagram being traced. Where many diagrams are to be taken the theoretical outline of the tunnel is printed on the record sheets before the diagrams are traced, so that the divergence between the actual and the required section can be seen at once (as in Fig. 3). Diagrams taken of the tunnel excavation in advance of the lining serve to keep the foreman informed at all times as to whether the tunnel is being properly driven and what trimming is necessary.

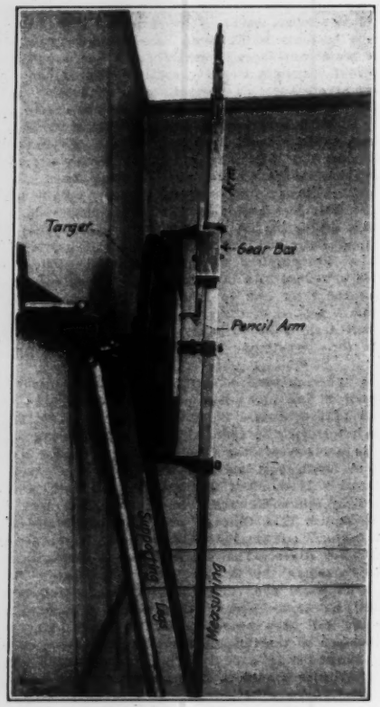

Fig. 2. Attachment of Measuring Arm and Recording Mechanism to the Target.

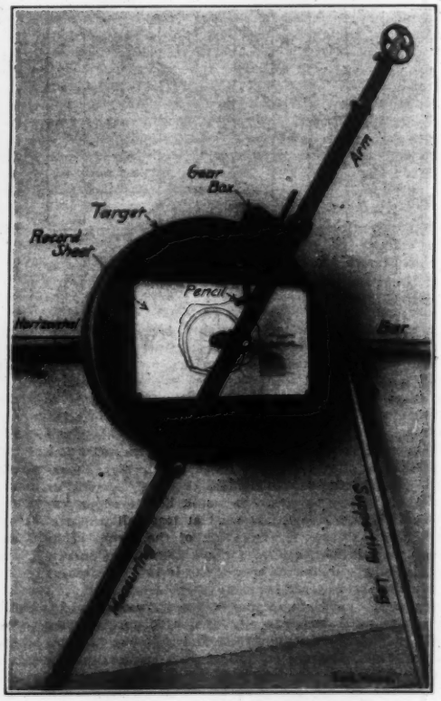

Fig. 3. Tunnel Cross-Sectioning Instrument in Position and Tracing Actual Cross Section Upon a Diagram of the Desired Completed Section.

PROCEDURE FOR MUNICIPAL WATER-WORKS construction by San Francisco has been recommended for execution in the following order in a summary report by Mr. Marsden Manson, M. Am. Soc. C. E., City Engineer of San Francisco: Construction of Lake Eleanor dam and main canal therefrom; letting of contracts for cast-iron pipe for the city delivery system, for wrought-iron pipe lines for the valley and bay divisions, and for the mechanical equipment of the power and pumping stations; acquisition of rights of way; construction of the city distributing system and nearby storage reservoirs; construction of the Tuolumne main canal, diversion dams, telephone and power stations and transmission lines in the Sierras; construction of pipe lines and appurtenances of the valley and bay divisions; the final constructions and connections of the pumping stations, telephone and power transmission lines.

DUST PREVENTION WORK ON MACADAM ROADS in Baltimore County, Md., is outlined as follows in the 1909 report of Mr. Henry G. Shirley, Engineer Baltimore County Roads, Townson, Md., as follows:

Owing to the number of miles of macadam roads in the suburban section near the city and the heavy motor traffic to which they are subject, it became imperative that some steps should be taken to alleviate the dust nuisance and preserve the surface of the macadam. About 40 miles of macadam were treated with a 40% asphalt oil manufactured by the Standard Oil Co. The cost of a road 12 ft. wide averaged about $120 per mile, according to the amount of sweeping required and the quantity and cost of washed gravel or sand spread on the surface after the oil was applied. The surface of the macadam was first swept with a horse sweeper to remove the dust, and the oil applied cold from a 1,000-gal. tank wagon with a Studebaker distributor. About two miles were treated in a day, depending on the distance the material had to be hauled. The results were satisfactory, the dust being completely laid and the surface preserved from raveling. Asphaltoilene was applied on First St., South Ave. and Rogers Ave., Mt. Washington, and up to the writing of this report has been entirely satisfactory, laying the dust and forming a surface resembling sheet asphalt. On these roads the cost was 6 cts. per sq. yd., not including the washed gravel. "Tarvia A" was applied on Ingleside Ave., from Edmondson Ave. to the Frederick Turnpike. The macadam surface was swept clean; the tarvia was heated and allowed to flow over the surface, being swept in with brooms. After the tarvia had sufficiently penetrated it was covered with stone screenings and rolled. The cost of this work was about 10 cts. per sq. yd. A bituminous macadam was laid on Roland Ave., from the city limits to the University Driveway, using the mixing process and a heavy asphaltum binder. Park Heights Ave. is being resurfaced under the State Aid Law, using the pouring process.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.
220 BROADWAY, NEW YORK

BRANCH OFFICES
CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
SAN FRANCISCO: Monadnock Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
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A marked feature in the recent development of concrete mixing machinery is the very general application to mixers of ordinary size of auxiliary apparatus for delivering the charges of raw material, and the occasional application of apparatus for handling the finished concrete. This was made very evident at the Cement Show held recently in Chicago, where concrete mixers made by a score or more of different manufacturers were on exhibition. A large majority of the mixers of the revolving drum type were equipped with power-operated charging hoppers or buckets. This equipment facilitates the work in two ways: (1) it reduces the amount of wheeling for the materials, and especially wheeling up inclines to reach the charging platform, which is frequently a cause of delay or interruption in the steady progress of the work; (2) it practically increases the capacity of the mixer, since the material for one charge is being got ready while the previous charge is being mixed. As soon as a batch of concrete is delivered, the complete charge for the next batch is dumped into the mixer. This takes but a few seconds, whereas a much longer time will be required if several loads of material for the charge have to be wheeled up and dumped into the mixer.

The charging apparatus, of course, is variously arranged in different machines. In a majority of cases, it is some form of combined hopper and chute, the smaller end being pivoted near the charging hole, while the hopper end (with hoisting cable attached) lies on the ground so that it can be readily loaded with the sand, gravel, stone and cement forming the charge. In some cases, however, an elevator bucket is used, traveling on vertical or inclined guides. In either case, the hopper or bucket is lowered for convenient loading, and then rapidly raised to deliver the charge into the mixer. Continuous mixers, of the shaft and paddle type, are rarely fitted with such apparatus, as the materials are supplied continuously and in small quantities to feeding hoppers. There is at least one make of machine, however, in which a vertical elevating conveyor of the bucket type is used to feed sand to the mixing trough.

A few of the machines exhibited had apparatus for handling and delivering the concrete, and there are evidently wide opportunities for further developments in this line. In some of these machines (intended specially for street work) a dumping bucket travels under a horizontal revolving boom, being operated by a cable. This bucket receives the batch of concrete from the mixer and delivers it at any point within the sweep of the boom, ready to be leveled and tamped. Belt conveyors on booms operated in the same way have been used also. In another machine (intended specially for building work) the mixer delivers the concrete into an elevator bucket traveling in a light steel tower extending above the height of the building. At the level of the floor under construction is attached a chute through which the bucket discharges the concrete into wheelbarrows or wheeled tubs for distribution. For narrow work, such as a bridge floor, the concrete in some cases has been delivered by gravity direct from the mixer by means of inclined troughs, the mixer in this case being purposely elevated on a car or wagon bed.

Another matter to which attention was drawn by the machines at the exhibition was the very large number of self-contained units, each having mounted upon its frame the mixer, the motive power, the water tank, and the charging hopper and concreting bucket, with their hoists. Thus one man could control the entire series of operations of charging, mixing, discharging and delivering the concrete. The motive power consists either of electric motors, or steam or gasoline (or even alcohol) engines. The steam engines are not very satisfactory for work in cities, as with the firing of small boilers there is apt to be a smoke nuisance. In probably a majority of these self-contained units, the plant was mounted upon wheels for convenient transportation, either from one job to another or (as in the case of street work, etc.) to keep up with the work as it advances and so maintain a minimum haul of the concrete from the mixer to the place of deposit. For the smaller classes of work, such as bridges, culverts, buildings, sewers, etc., these complete portable units present many advantages.

For large works whose construction will extend over considerable periods of time, and where great quantities of concrete are required, large stationary plants are more suitable, with mixers of large capacity and with a special equipment of auxiliary apparatus arranged to suit local requirements for the handling of raw material and the delivery of concrete. Such extensive plants, however, are not likely to be represented at an exhibition, and it is the combined display of concrete machinery at the Chicago exhibition which has suggested the foregoing remarks.

The great diversity of laws passed by the fifty sovereign commonwealths of the United States serves to meet varying local conditions due to differences in population, industry, geographical location and the like. It also serves a further beneficial purpose in that it affords an opportunity for experiment with various attempted solutions of the same general problem. But many subjects of legislation involve matters of equal and common concern to several or all the States of the Union, and under diverse legislation may give rise to no end of trouble.

For a number of years past a national organization has been working for the extension of uniform legislation. The subject was recently taken in hand by the National Civic Federation (headquarters in New York City) which held a conference on uniform state legislation at Washington, D. C., in January, 1910. A number of resolutions were passed favoring uniform legislation on topics which concern many of our readers. Besides recommending uniformity in such matters as negotiable instruments, bills of lading, vital statistics and taxation, the conference passed resolutions relating to industrial accidents, conservation of forests, regulation of water-power and uniform governmental accounting. It also endorsed the bill pending before the Congress of the United States establishing a bureau of mines in the Department of the Interior, and urged the various states to cooperate with the Federal Government by procuring "uniformity upon which intelligent state legislation may be based."

Regarding industrial accidents, the resolutions adopted cited the fact that "present remedies for compensation for industrial accidents throughout the various states are slow, uncertain and wasteful," and that there can be no equitable solution of the problems presented which is "based only on the fault of the employer." Mention is made of the fact that no less than 23 foreign nations "have bettered, and in some instances solved, the problem on the basis of workmen's compensation acts." Similar legislation by American states was recommended.

Uniform state laws for regulation of water-power on non-navigable streams, and uniform state regulations governing water-power on navigable streams and cooperation between the governments of each state and the United States, were recommended.

After reciting the steps taken by the National Municipal League, the American Association of Public Accountants, the Government Accountants' Association, and other bodies looking to improvement and more uniform public accounting, and after reciting the fact that Ohio, New York, Massachusetts, Indiana, Rhode Island, Colorado, West Virginia and Wyoming have established "uniform accounting bureaus or boards of control," the conference resolution urged that other states "enact such measures upon confirmatory lines." Following this resolution was one which stated that 21 states have passed laws regulating public accountancy, and urging that further legislation of this sort, which, of course, should be uniform, be promoted.

All these subjects are worthy objects for well-advised uniform legislation. Perhaps the most pressing need of the present movement is careful legislation designed to make accidents to industrial employees a charge on the industry, rather than the individual workman, as is now the practice in this country. The sweeping provisions of the British "Workman's Compensation Act" of 1906 are set forth and their legal bearings and their status elucidated in a book which was reviewed on p. 24 of our Engineering Literature Supplement for Feb. 17, 1910.

The somewhat remote province of Saskatchewan, in northwestern Canada, has recognized the importance of the engineer in health-protective work by engaging Mr. T. Aird Murray, M. Can. Soc. C. E., of Toronto, as Consulting Sanitary Expert to the Bureau of Public Health. Health affairs in that province are to be administered by a single commissioner instead of by a board. The latter is contrary to the usual practice in Canada and the United States, but there are good precedents in the latter country in the important states of New York and Pennsylvania. The Saskatchewan Bureau of Public Health is to have authority over plans for new water-supply and sewage works. Obviously, if a state or provincial board or department of public health is to have control over such engineering matters as these, the services or advice of an engineer become necessary. One by one our own states are putting at least one representative of the engineering profession on their state boards of health. Besides this, all of the more progressive states have given their boards power and money to employ sanitary engineers either on a whole-time or part-time basis. We are particularly pleased to note that the state of Georgia has recently provided for the services of an engineer. This is noteworthy, in view of the general health-protective inertness of the South. It should be noted, however, that the North Carolina Board of Health has had an engineer member for some years.

Both Governor Hughes of New York and Governor Fort of New Jersey have joined in the movement for reducing the number of elective offices to be filled by popular vote. The aim of this movement, which has the effective name of "The

"Short Ballot," is to concentrate the attention of the voters upon a few men, and thus enable them not only to vote intelligently, but to follow the actions of the men whom they elevate to office and call them to account if they fall far short of fulfilling their duties. A further object is to enlarge and perfect the responsibility of the heads of state and city executive departments by giving them the power of choosing their associates and subordinates in executive positions.

An amendment to the State Constitution of New York is required in order to make possible needed election reforms in that state. Such an amendment has been introduced in the State Legislature. It provides that after taking effect, only the governor, lieutenant governor and state comptroller would be elected by popular vote. It would make the secretary of state, state treasurer, attorney general and state engineer and surveyor subject to appointment by the governor.

Our readers will appreciate the desirability of the proposed change, particularly as regards the state engineer and surveyor. Nothing could be much more absurd than having the voters of a state of ten million population decide who shall occupy the important position of state engineer.

The suggestions of Governor Fort of New Jersey have been directed more particularly to municipal officials. The same general principles apply here as governor or should govern the filling of state offices.

An organization to promote the short ballot was effected a few weeks ago in New York City. This, combined with many other agencies which are working toward the same end, is sure to bring about many needed changes within a few years.

The shifting of railroad traffic overnight from an old location to a new one and the changing of railway bridges in a day have been so often and so smoothly done that such works excite at most only mild surprise. But the news that a 60-mile interurban electric railway was changed "over night" from alternating to direct-current operation has elements of novelty which make it unusually interesting.

In the first place, even a hasty reading, of the account printed elsewhere in this issue, shows that months of preparation were needed here also. New and different cars had to be secured and all the trainmen had to be instructed in their use, before a single passenger could be safely carried. Transmission lines and feeders had to be erected ready for the few final connections. Temporary substations were needed in which to operate the power apparatus about to be discarded until the hour of change. All these things were made difficult by the need of keeping high voltages on the old lines and apparatus all day and nearly all night, up to the time of actual change.

The casual reader of the account of the radical change made in the operating system of the Washington, Baltimore and Annapolis Electric Ry. should not jump at the conclusion, we think, that the single-phase idea is passing, hardly before its youthful development is well begun. The failure of the alternating-current system on this line may be traced to purely local conditions, which, it is now seen, make the line unsuited to reap the benefits claimed for single-phase operation under favorable conditions. For instance, the use of static transformers could not eliminate moving machinery, with its more expensive care, from the substations because of the local demands for lower-voltage, direct-current, overhead circuits at all terminals and in the repair yards. The variety of running equipment thus made necessary brought more complicated and cumbersome car equipment, not easy to inspect and to maintain and therefore less reliable than desired. The old rolling stock was, at the time of delivery, the heaviest used on any interurban electric road—either direct-current or alternating—requiring probably more than common skill in handling and certainly more than an average amount of power to operate. But the most important factor of all was the need of running through cars into and out of the heart of Washington, in order to attract traffic. It was found impracticable to sufficiently reduce the weight of the high-speed, single-phase rolling stock, in this instance, to suit the strength of the conduit yokes supporting the city tracks. This reduction was believed practical with high-voltage, direct-current equipment. Thus the objections of prospective passengers, to the inconveniences and delays of changing, proved more serious than anticipated and may be cited as the chief underlying reason for changing the whole system.

The Forest and Stream Flow Controversy Continued.

Is the forester, the hydrographer, the meteorologist, the army engineer on river improvement, or the private engineer engaged in water-supply development best fitted to pass on the relation of forests and deforestation to stream flow and yields? One or more leading members of each of these classes has taken a prominent part in the discussion of this question which has been going merrily on for the past two or three years. In this issue we reprint large portions of a recent contribution to the subject by Mr. W. A. Moore, Chief of the U. S. Weather Bureau, together with a short paper by Maj. W. W. Harts, U. S. A., summarizing a study of the Cumberland and Tennessee rivers with regard to the possible effect of deforestation on those streams. We also publish a letter from Mr. R. C. Beardsley, an engineer in private practice, discussing various phases of deforestation and stream flow.

In general, all three of the writers named, who have taken up the subject quite independently, agree in maintaining that other things than deforestation are responsible for floods. The first two men whom we have named place variations in stream flow squarely upon corresponding variations in precipitation. Mr. Beardsley lays particular stress upon the drainage of swamps and bogs and other quickeners of run-off, all quite independent of forests. Some of his reasonings or conclusions seem inconsistent, but his remarks on flood heights are worthy of consideration, and tally with some of the remarks of the two other writers. Mr. Beardsley's advocacy of reservoir construction as a means of flood prevention will perhaps give some comfort to Mr. Marshall O. Leighton, who is the target for much of the criticism sent from the bows of all three writers; but reservoir construction seems quite as impracticable to many as does the deforestation argument.

It is a cause for regret that so much of the discussion of forests and stream flow, not only of late but also for years past, has been partisan rather than truly scientific. The friends of the forests are largely responsible for this, for their sweeping claims have often been either so unsupported by data or the data presented have been so questionable in origin or in application as to arouse strong adverse criticism and equal recklessness in the use of data.

Unfortunately for all the disputants and for the advancement of scientific knowledge the data needed to settle the forest and stream flow controversy beyond reasonable question are limited. It is hard to find any reliable figures on percentages of forested areas to total areas at different periods. Rainfall records were scanty and subject to various inaccuracies until within the past two or three decades. The stations for observing rainfall are none too numerous now, and are notably few at high altitudes. Stream run-off records were still more scanty and inaccurate until the past five or ten years. River stages, more particularly at one or the other extremes, have been recorded at some points for a long time, but the accuracy of most of the American records up to a few decades ago is subject to question, and whether questionable or no conclusions drawn from river heights may be vitiated by markedly changed conditions affecting main channels at observing stations, most of which are located in cities, which latter have encroached in various ways upon the banks and channels of streams.

These examples of incomplete data for judging the relation between forests and stream flow are by no means all that might be cited, but they are sufficient to show that any argument based chiefly on one line of data is rendered doubly misleading by the incompleteness of the data on that line. If the data selected are chosen with a view to supporting a thesis, as the writers whose opinions are voiced elsewhere in this issue claim to have been the case in some of the recent discussions, then so much the longer will it be before the truth is finally established.

We believe that all who have been engaged in these recent controversies have been inspired by a desire to help on what they regarded as a worthy cause or else to oppose what they believed to be conclusions based on faulty premises. This goes far towards excusing special pleading but it does not justify it.

It seems particularly unfortunate that different bureaus of the same government should be pitted against each other in matters involving the use of what is supposed to be scientific data. That is virtually what has happened, since the Chief of the Weather Bureau has supplied the House Committee on Agriculture with arguments to combat those contained in public documents prepared by or under the direction of the late Chief Forester and the Chief Hydrographer of the Geological Survey. The opposing arguments are now being used, it appears, on either side of the bills before Congress to establish forest reservoirs in the White Mountains and in the Southern Appalachians.

In these jottings we have not so much intended to take sides in a controversy as to make plain that much of what is being written on the forestry and stream flow question is highly controversial and largely partisan in character and should be judged accordingly; and that no one interested solely in the truth rather than in the success or failure of certain Congressional bills or national policies should overlook the very incomplete and unsatisfactory character of many of the data which are being used by the opposing sides, generally for lack of anything better.

As illustrating how futile much of the discussion is, when based on insufficient records of the vagaries and variations of nature, we call attention to the fact that before Mr. Moore's citation, with approval, of assertions that the floods of the Seine had decreased with deforestation was off the national press at Washington we had all read in cable dispatches from Paris that the flood of January, 1910, slightly exceeded all previous records, including the famous flood of 1615. It is only fair to Mr. Moore to say that after all this goes to prove his main thesis, that floods rise and fall with total precipitation on the drainage area; to which we may add the well-known fact, mentioned by Mr. Moore, that in the case of a large drainage area it may seldom happen that the rainfall is so distributed in both time and area as to bring the maximum run-off from each tributary to the main stream at almost the same moment. It so happens that almost while the foregoing words were being written there came to hand a London contemporary, "The Contract Journal" of Feb. 16, with this statement included:

> It was, perhaps, impossible to foretell that the speed of the flood flow on the usually slow Marne would exceed that of its more rapid partner the Yonne, causing their almost simultaneous discharge into the already swollen Seine; nor, perhaps, could it be inferred that this would be followed in a few days, after a barely perceptible drop, by a second more rapid rise of the Yonne, which may be, and probably was, due to the melting of the snow on the plateaux of Morvan owing to the unseasonably mild weather. Added to this, from Jan. 22 to Jan. 26, snow or rain fell almost without a break, and it was not until the 27th that any improvement in the condition of things was observable.

Perhaps we should have prefaced this quotation with the following brief sentence from the same source:

> Owing to the wet summer of 1909, it would seem that the conditions of things were almost reversed; the land of the basin of the Seine and its tributaries would be in its winter state of saturation during the greater part of the year, and any heavy rain would at once cause a rapid increase in the surface drainage.

Under such a combination as the simultaneous flood stage at their mouths of two tributaries usually reaching flood at different periods and an entire drainage area supersaturated what does it matter how much or how little of the drainage area was forested, and of how little avail are

records extending to centuries unless they go back far enough to take one of its nature's most infrequent cataclysms?

The Cost of Terminal Handling in Freight Transportation.

A good deal has been said in recent years about the importance of good terminal facilities for economical freight transportation. We wonder if engineers generally realize how important this matter of economical terminal handling has become. We wonder if they realize what the relative importance is of improvements to terminals compared with improvements to a railway line itself or to a waterway.

We wish to forcibly impress upon our readers' minds the truth regarding this matter of terminal facilities. In order to do this we venture upon the following deliberate exaggeration:

The total cost of moving freight from its origin in one city to its destination in another is THE SAME for all distances less than 100 miles.

The cost of terminal handling in cities is so great compared with the cost of moving a train or a vessel, when loaded and started on its journey, that the latter can be ignored.

We have confessed beforehand that this is an exaggeration; but it is an exaggeration after all which hits nearer the truth than many statements which profess to be mathematically exact.

Let us take a concrete example. Suppose a manufacturer in Philadelphia wishes to send a ton of freight to a merchant in New York City. The freight is loaded onto a truck at a labor cost of say 25 cts. It is hauled to the freight station and unloaded there at a cost of say 50 cts. The railway company's employees at the freight station load it on hand trucks and haul it by human muscle to a freight car into which it is packed. The total cost, to the railroad company, including the clerical labor in connection with the billing, weighing, recording, etc., will probably average at least 40 cts. By and by a switching engine comes along, pulls the loaded car out of the freight house and by various devious back and forth motions through the labyrinthine yards, the car is finally assembled with others in a freight train bound for New York. If we add to the actual operating expenses of switching locomotives, pay of yardmen, etc., the interest on the valuable land which these switching yards occupy, it will probably be found that the railway company expends from $2 to $5 per car, or 10 cts. to 50 cts. per ton, say 25 cts. on the average, from the time the car is loaded till it starts on its journey.

Passing now to the other end of the journey, there is more switching in the extensive yards at Jersey City, by which the car is finally assembled with others destined for the same point and transferred to a car float. This is towed to a slip on the water front of Manhattan Island and the car is unloaded in the freight station on the pier. Its contents are loaded on trucks and hauled through the streets to the consignee's store. For the cost of handling at this end of the journey, we will take the figures given in a published report by Mr. Wm. J. Wilgus, M. Am. Soc. C. E., than whom it would be difficult to find a better authority.

Mr. Wilgus's figures are as follows:

	Per ton.
Terminal costs on the New Jersey side of the North River (average of all railways)	15 cts.
Lighterage	80 cts.
Terminal cost on waterfront, Manhattan Island	50 cts.
Cartage expenses in New York City borne by shippers	80 cts.
	$2.25 cts.

Mr. Wilgus remarks that these estimates of average cost are low rather than high. Adding to these the terminal expenses at Philadelphia, which we enumerated above, amounting to $1.40, we find that the terminal charges at both ends of the journey amount to $3.65 on a ton of freight.

Now how much—or how little—does it cost the railway to haul the freight from Philadelphia to New York, a distance of approximately 90 miles? We believe that we are entirely safe in saying that the total cost to the railway company of hauling loaded cars on the open road, on lines of easy grades and large traffic, where long trains can be handled, is less than 3 mills per ton-mile, including in this not only operating expenses but interest on the investment in permanent way and rolling stock, apart from investments in terminals. This estimate is for merchandise traffic. Bulk freights of coal and ore and grain are hauled for considerably less cost because they can be handled in cars which are loaded much more nearly to full capacity than is possible with merchandise freight. It is also possible to use 100,000-lb. steel gondolas for coal and ore, which effect a further large gain in percentage of paying load.

Taking this figure of 3 mills per ton mile as the cost of hauling the ton of freight from Philadelphia to New York, the total cost for the 90 miles is 27 cts., which compares with total terminal expenses of $3.65. Therefore, if the above estimates of average cost are accepted as correct, *the cost of getting a ton of freight started on its journey at one end and handling it from the Jersey City terminal to the consignee's store at the other end is NEARLY 14 TIMES AS MUCH as it costs to haul the goods all the way from Philadelphia to New York.*

These figures, we believe, will stand searching analysis and criticism. The estimates for the cost of terminal handling are fully corroborated by the statistics given by Mr. H. McL. Harding in a paper published elsewhere in this issue. Mr. Harding has gone to great pains in collecting from many sources figures as to the cost of handling freight in railway and steamship terminals in many cities of the United States. His figures, however, high as they are, probably omit in most instances to include the charges on the immensely valuable real estate which railway terminal yards and freight stations in large cities generally occupy.

Some may contend that our estimate of 3 mills per ton-mile for the cost of hauling merchandise freight over the road, apart from all expenses at terminals is too low. To any who hold such an opinion we suggest a study of the Interstate Commerce Commission's statistics. These show for the year 1907, for the railways of Group III. (the states of Ohio, and Indiana with southern Michigan) an average *revenue* per ton-mile on all freight carried amounting to six mills per ton-mile. This includes profit as well as cost of service. *It includes all the terminal expenses.* It includes all the business on lines of light or moderate traffic. The average freight train load in this district was only 446 tons; but under the conditions we are assuming, an average freight train load of 1,000 to 1,500 tons would be expected.

Taking all these facts into consideration, it would seem that the above assumption of three mills per ton-mile on merchandise freight is high rather than low. Suppose, however, for the sake of argument, that the cost is four mills or even five mills. The computation still shows that the terminal expenses on a ton of freight are many times as great as the cost of hauling it over the road.

And now let us assume a much longer haul. Suppose the ton of freight is to be sent from a concern in Chicago to a firm in New York City. The terminal expenses will be no less, certainly. In fact switching expenses in the maze of freight yards which gridiron the industrial portions of Chicago are likely to be much higher than we have assumed at Philadelphia. The cost of hauling over the open road will be less on the long haul from Chicago to New York than on the short haul of 90 miles from Philadelphia to New York. Let us leave it, however, at the same figure, three mills per ton-mile. The comparison then stands as follows:

Cost of starting a ton of freight on its journey and receiving it at the end	$3.65
Cost of hauling it 1,000 miles, from Chicago to New York	3.00

It may be objected that this comparison is misleading, since we have included in the terminal expenses costs borne by the shipper and consignee, as well as the costs borne by the railway company. Let us make a comparison, therefore, of the railway terminal expenses with the expense to the railway for hauling the ton of freight on the road. It is as follows:

Cost to the railways of handling at terminals	$2.10
Cost to the railways of the 1,000-mile haul	3.00

If, as is probably the case, the road expenses are as low as 2½ mills per ton-mile, and the actual terminal expenses are higher than our estimate, then it actually costs the railways more to handle a ton of freight at the terminals in the two chief cities of the country than to haul it all the way from one to the other.

Alter these estimates as you will, within the bounds of reason and probability; the fact still stands out in glaring relief that it is in the terminal handling and not in hauling over the open road that the great opportunity lies for further reduction in the cost of transportation. Marvels have been accomplished in the past twenty years in reducing the cost of railway freight transportation. Many hundreds of millions have been spent in cutting down grades, building cars and locomotives of larger and still larger capacity and in rebuilding track, rolling stock and shops to suit these changes. As a result we have reached a point where further possible reductions in the cost of hauling on the open road are actually of trivial importance, except on the longest hauls. The task before the railway engineers of the present generation is the reduction of terminal expenses.

And what is true of railway transportation is true of water transport. On the water as on the railway the engineer will do well to forget all about the mills or fractions of a mill per ton-mile which it will cost to move the freight and concentrate his attention on the question what it will cost to get the freight started on its journey and taken care of it at the journey's end.

A great deal has been said about the phenomenally low transportation costs attained in handling ore and coal on the Great Lakes, and the advocates of huge Federal appropriations for waterway improvements have credited these low costs to the deepening of channels, which has made possible the use of larger vessels. The fact is, however, that the most potent factor in lowering transportation costs on the Great Lakes has been the improvement of terminal facilities. It is the big ore shovels and the cantilever cranes, the car dumping machines and the hopper-bottom cars, the huge ore pockets and the stock-piling and recovering systems that have lowered transportation costs on the Lakes to a point not attained anywhere else in the world.

It is well known that railway freight rates in the United States are far below those prevailing in Europe; and the familiar explanation is that the difference is due to our larger cars and locomotives, our longer hauls and the greater proportion of bulk freights. All these are important, indeed; but may not another explanation be found in the greater proportion of American freight traffic on which terminal expenses are small because it is handled directly to or from the private siding at a mill or mine or warehouse? Conditions in America have permitted the laying of side tracks to thousands of industrial plants which under European conditions would have had to be content with a team haul to the railway station.

Again, as we have very recently emphasized in these columns, the much debated question as to the relative cost of rail and water transport hinges *entirely* on the matter of terminal facilities and expenses. Shipments between New York and Boston, for example, where the destination is on or near the water fronts of the two cities, can go more cheaply by water than by rail. But a concern which has its own siding on which railway cars can be received and delivered usually finds the water route too expensive to patronize, no matter how low a steamer rate may be quoted.

The facts we have been reciting may seem to some too obvious and well known to need elucidation in this manner; but even though they be obvious to some engineers, they are, unfortunately not understood or appreciated by the

business world. Even the railway traffic departments, which should be posted on these matters, are generally ignorant as to the enormous proportion which terminal expenses bear to road expenses. Yet the facts which prove our contentions are before their eyes. In the whole of the United States, there is one switching locomotive in service to every 3½ freight locomotives in road service. Ten years ago the proportion was four freight locomotives to one switcher. In the states containing the great railway centers the proportion is higher. On the New York Central there is one switching locomotive to three freight locomotives. The Louisville & Nashville shows about the same proportion, and one of its divisions has more switching locomotives than freight locomotives. And the cost of switching cars in city terminals is usually trifling compared with the cost of handling in freight houses, and of loading and transferring freight.

In the above discussion it will be noticed that we have taken the terminal expenses in the largest cities. In the smaller cities the terminal expenses are, admittedly, considerably less, and at country stations they may become almost negligible. The ideal condition for the railway, however, is the condition where it receives and delivers loaded cars directly on the shipper's private siding. Here the terminal expense to the railway is almost wholly eliminated, and to the shipper it is reduced to the lowest possible amount.

It is a question of great importance (both to the railways and to the public) whether radical revisions ought not to be made in railway rates because of the great disparity in terminal expenses. While switching charges are in some cases figured separately on shipments, for the most part the railways lump terminal expenses and road expenses together in making up freight rates. We surmise that careful investigation would show that the railways are actually losing money in some cases on freight handled in expensive terminals, and are charging unduly high rates on other freight where the terminal expenses are practically nothing.

If this surmise is correct, then surely the injustice ought to be corrected. There are forces enough tending to build up the city at the expense of the country and to build up the great commercial centers at the expense of the smaller cities without freight rate discrimination. It is to the interest of the railways to build up the industrial plants and the smaller towns and cities scattered all along the lines, where terminal expenses are small, rather than the great cities where the railways are forced to spend millions on enlargement of terminals to keep pace with the traffic.

Again, the chief commercial centers are in continual rivalry over the question of relative freight rates. The trade which jobbers and wholesalers can secure depends on the freight rates which their customers have to pay. Hence the Boards of Trade and other commercial organizations of important cities are all the time working for railway rates which will give them an advantage over rival cities or will checkmate some advantage which their rivals have secured. The Interstate Commerce Commission and the Courts are kept busy by these controversies between rival cities. The idea that the distance hauled should be the controlling factor in fixing the railway rate has been embodied in our Federal statutes in the "long and short haul" clause of the Interstate Commerce law. Yet, as we have shown at the outset of this article, it is the relative terminal expenses that should govern the rates to two different cities. Compared with these, even great differences in the length of haul are trifling.

If a Board of Trade or Chamber of Commerce wishes its city to gain an advantage over rivals, it can secure that end most effectively by reducing the terminal expenses within its borders. One of the most effective methods of doing this is the provision of freight warehouses at the railway terminal. Under the ordinary commercial method, a wholesale merchant buys certain goods from a manufacturer. These goods are shipped to the wholesale merchant and are hauled from the railway station to his store. The wholesaler sells these goods to the retailer and the goods are then loaded on trucks and hauled back again to the railway station. Evidently here is needless transportation which might be cut out. Hence in a number of cities freight warehouses have been established beside the railway yards. The consignee receiving goods has them transferred from the freight car directly to the warehouse and when they are sold they are taken out of the warehouse and placed in the car. Hauling both ways through the streets and storage in the expensive space near the business center where the merchant has his store are both eliminated. There is an enormous field for reducing terminal expenses by the construction of such warehouses. The city supplied with such facilities has an advantage over a rival as great as that possessed by a manufacturer who has a railway siding running into his works compared with a rival who hauls bulky products and supplies a long distance to and from the railway station.

There are other methods by which terminal costs may be reduced in the future. Mechanical methods of handling freight, such as those described by Mr. Harding can be introduced in place of human muscle. Hauling through the streets may be done by trucks of five to ten tons capacity driven by mechanical power instead of by trucks of a quarter of that capacity hauled by horse power. Better yard arrangements and systems of organization will expedite the work of switching and make more efficient the valuable land on which this work is constructed.

Most important of all, we believe, however, will be the avoidance of terminals wherever that is possible, the diversion of freight lines around cities instead of passing through them, the building of factories in the country instead of in the city, the shipping of materials direct from producer to consumer, instead of passing them by devious routes through middlemen's warehouses. It is by such methods that the engineer must seek to effect further reductions in transportation costs.

LETTERS TO THE EDITOR.

Tests of the Oil-Gas Producer on the Yacht "Wayward."

Sir:—An article entitled a "Suction Oil Gas Producer" published in your issue of February 24th, 1910, is somewhat misleading in its context. It might be gathered from a perusal of this article that Mr. John L. Bogert had certified to the accuracy of all the statements contained therein relative to a trial of the yacht "Wayward" in September, 1909. As a matter of fact Mr. Bogert was simply requested to pass upon one question, and that, whether or not under substantially the same conditions the yacht could cover the same distance using fuel oil only with one-half the consumption of fuel oil that she required of gasoline when the latter fuel was substituted for the former. Mr. Bogert found that such was substantially the case, and he certified in writing to such finding, but the other facts contained in the article were the results obtained by other and independent investigations. It is only fair to Mr. Bogert not to make him responsible for any other statement than that the "Wayward" with substantially the same condition of hull, engines, equipment, tide, and wind did consume but approximately one-half the quantity of fuel oil in covering the distance from New York City to Stony Point and back again, that she needed of gasoline to cover the same distance.

Trusting that I have made myself clear as to this point in justice to Mr. Bogert, I remain, yours truly,

Hydro-Carbon Converter Co.,
By Thomas A. Nevins, Pres.

37 Wall St., New York City, Feb. 26, 1910.

A Lecture to the Editor.

Sir: How would it do for the editor to just publish the engineering news and let the public and engineers draw their own conclusion. Your fertile mind seems to be bubbling with bitterness against all waterways improvements in the west, and so much so that it indicates pecuniary interests. It should be remembered all journals are private money-making institutions, whose services are to sell, which no doubt accounts for the change in front of the Chicago "Record-Herald," "Interocean," and "Tribune."

Railroad interests are not in favor of water routes as has been stated by some. The engineers of the we I think, are satisfied with the preliminary report of National Waterways Commission which you charact istically strived to belittle.

You often refer to water "boomers" and "vision dreamers," "salaried lecture bureaus," etc. Will the itor kindly name some of these salaried lecturers a salaried lecture-bureaus. It would be interesting know something more about them if they exist. It see to me it should not be the function of Engineering Ne to misrepresent and hint that our Representatives a Senators in Congress are so frail, intellectually a morally as to sanction a report in opposition to real facts and their convictions. The report is good a bristling with sound sense as engineers and everybo else in fairness must admit.

No doubt such influence will be brought that the sta of Illinois will hold her twenty million appropriatio until such time as it can be used for the purpose i tended and not allowed to drift into political use, to pr mote a governor's and others' political ambitions.

John Howe Peyton's article in your last number, Fe 17, is logical in one sense, but does not represent t administration of this Government or any other. I fact, no government could exist if conducted on str lines of corporations. By his course of reasoning near everything related with government expense is a swind on the "dear people" as he terms it. The Postal De partment, Navy, Panama Canal, the taking over of t Philippine Islands, the Humbug Monroe Doctrine th has cost us millions, and will some day breed a sca on our nose.

No interest in this country has ever received so mu public aid as railroads, both by the Federal Governme and every town and county, along the routes; and wh has been the result? Simply to boom railroad corpora tions. The Government made them, as they made Ca negie and the Steel Trust, boomed land in the west an depreciated it in the east, more than 50%, developed and promoted indolence, in the yet unhalf developed eastern states, caused the premature destructance of our forests for ties and lumber and all kind of vandalism run rampant for speculation on the "Gould theory—Th public be damned." I simply allude to this to show by reasoning on Peyton's theory "the dear people" a he calls them are always swindled, and particularly by railway.

The Government collects money directly, and indirectly, from the people, and returns it directly, and indirectly, and perhaps foolishly in many instances, but still we progress in wealth and better institutions. I hardly expect you will publish this, but if you will kindly read it, it will be worth my while, and I hope yours.

Very respectfully,
R. J. Mershon, M. W. S. E.

Chicago, Feb. 21, 1910.

[If our correspondent really believes that Engineering News' editorial policy is a matter controlled by bargain and sale, probably nothing we could say here would convince him to the contrary.

The charge is so often made, however, that the railways are using their influence to defeat measures for expending public funds on waterway improvements that a word regarding that charge may be worth while. So far as expenditures on seacoast harbors are concerned, it will be conceded at once that the railways have no object in opposing such works. Improvements on the Great Lakes, too, benefit the railway companies materially, since the bulk of the shipping business on the Lakes is directly or indirectly carried on by railway companies. There remains then only the matter of expenditures on inland rivers and canals. To the best of our knowledge and belief, the railways have taken no active part in opposing the campaign for waterway improvements. The chief operating officers of our railways understand perfectly that the railways have nothing to fear from the competition of any inland water routes. The railways would have no particular object, therefore, in opposing waterway improvements.

As public spirited citizens, the officers of railway companies may regret to see public funds wasted in constructing works which can never yield any public benefit commensurate with the cost; but they know well that any attempt by them to set the public right on the economics of transportation would be misconstrued and would do harm rather than good. Further, while the railways will suffer with other taxpayers from the wasteful expenditure of public funds, they will gain a large amount of traffic and travel while the work of waterway improvement is going on. In fact a very considerable percentage of any Government appropriation for waterway improvement will shortly

find its way to the railway treasury, in payment of traveling expenses, freight on materials and supplies, etc. Why then should the railways bother themselves to oppose legislation for waterways?

Referring now to the second paragraph of our correspondent's letter, we are mystified by his assertion that we "characteristically strived to belittle the report of the National Waterways Commission."

We published that report in full in our issue of Feb. 3 (being the only journal in the United States to do so), and we referred to it editorially in the same issue as "the most enlightening public document that has yet reached the American public upon this much debated public question." Is this our correspondent's idea of "belittling," or did he intend this assertion—and we hope his reflection in the first paragraph upon our honesty—to be taken in a "Pickwickian" sense?

Referring to the third paragraph of the letter above, the National Waterways Association is the chief organization which has engineered the agitation for waterway improvements. During the past year it has had at least two public speakers, traveling about the country addressing commercial bodies in behalf of waterway improvements.

As to the interpretation of the latter part of our correspondent's letter, we are in doubt. From his approval of Mr. Peyton's paper, however, we judge he thinks that the Government ought to undertake waterway improvements regardless of the fact that the waterway is obsolete and impotent as an instrument of economic transportation. In answer we would assert the principle that *we* believe should control Government expenditure. No expenditure of public money should be undertaken which does not promise an adequate return of one sort or other. The nation or state or city which loses sight of this principle starts on the high road to bankruptcy.

Finally we may relate that if the editor's feelings were ruffled by the aspersions in the foregoing letter they were soothed by the next letter received in the day's mail, the opening sentences of which were as follows:

Sir: I must write to tell you how pleased I feel at the attitude the News is taking on the important economic problems of the day. I am struck with your broad and progressive views on all municipal and economic policies.

So long as a due proportion of appreciation comes to us to offset the criticisms of those who chance to differ from us, we shall think it worth while to publish editorial opinions as well as "just the engineering news."—Ed.]

Forests and Stream Flow.

Sir: It is safe to say that never before in the history of this country has an economic question been so universally accepted and so worthily championed as the conservation of national resources. First introduced by our greatest of presidents and sanctioned by the governors of practically all the states, it would seem that it was a subject too thoroughly guarded to be attacked.

Water Supply Paper No. 234 is a reprint by the U. S. Geological Survey of the report of the National Conservation Commission, and it is this report which the writer wishes to criticise.

It is a habit with laymen to take for granted every statement published in a public document, but the writer believes that where the public interests are so vitally affected by a new theory it is the duty of the engineering profession to discuss such publication with a view to prevent future hasty conclusions being formed to support a popular propaganda.

The writer does not question the motives of the enthusiastic supporters of conservation, but it is his belief that their desire to believe certain things has biased their view and led to the resulting conclusions. The object of the commission's report was to prove that deforestration was the direct cause of an increase in floods, and that therefore some reforestration plan should be adopted to prevent this flood increase.

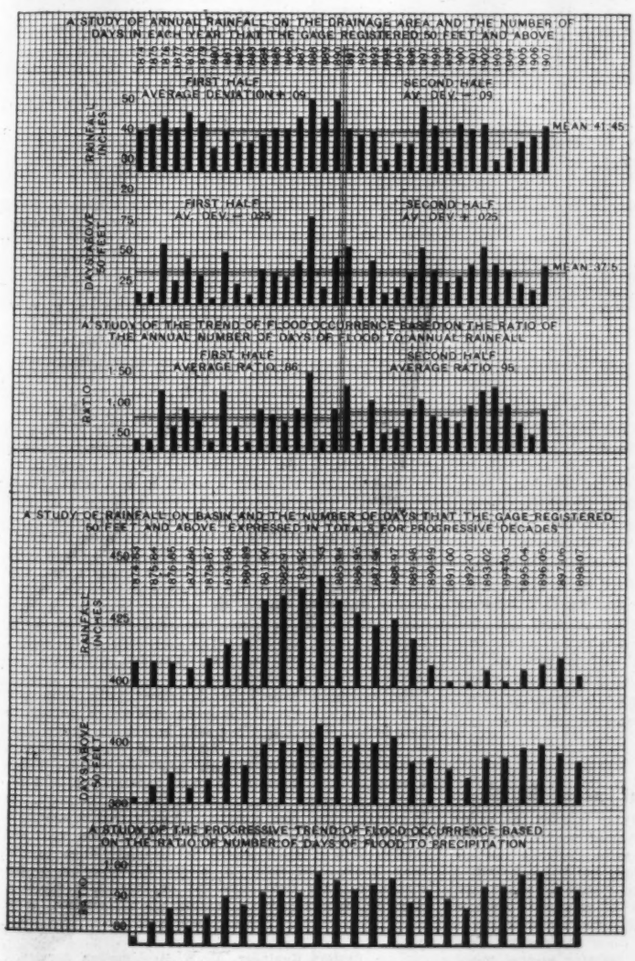
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FIG. 1. FLOODS ON THE CONNECTICUT RIVER AT HOLYOKE, MASS., 1874 TO 1907.

To prove this contention rainfall and flood diagrams were presented for a number of streams. (See Fig. 1 for one of these.) These streams are in localities where there has been active deforestation in progress for many years. The floods indicated are not the maximum flow recorded for a single day, but the number of days that the flow exceeded a certain amount. That is, the area of the peak, a, b, c (Fig. 2) of the flood rather than the height b d, is taken. The reason for this, as explained in the report, is that by this method only can the effect of rainfall be shown in its true relation to flood production. This, in view of the argument, leads to the assumption that deforestation increases the width of the flood peak base a c, which is contrary to the views of practically all reputable engineers, the reasons for which will be explained later.

On most rivers in the east there are two large floods annually, one occurring in the Spring and one in the Fall, hence the diagrams largely represent the duration of two extreme floods rather than the number of small floods. The diagrams giving the ratio of the floods exceeding a certain gage height to the rainfall are meant to indicate that a larger proportion of the rainfall passes off as flood water, and less is absorbed by the soil than formerly. It will be noted that the small flood does not show in these diagrams nor does the rainfall producing any particular flood. They merely show that there were so many inches of rainfall during the year and that the base of the flood peaks extended over a certain period.

The question then is (granting that the diagrams properly represent the respective rivers), what is the cause? It must be granted that large areas have been deforested. Cities have grown up, hundreds of thousands of acres of timber land have become farm land. Everywhere the drainage of the land has been improved. Then what one cause can be given credit for the flood increase indicated? Do forests diminish floods? Has this been proved by actual experiment? The writer has seen the most extreme floods in densely forested territory, namely along the White and Buffalo rivers in Arkansas. Here the oak and pine forests will

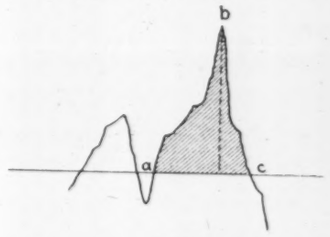


Fig. 2.

average 3,000 to 20,000 ft. of lumber to the acre, and yet the rivers will rise out of their banks after a few hours rain and go down again to normal all within a day. In the pine forests of the north where a thick carpet of pine needles forms a mulch, thus retaining a certain amount of moisture, we find the rivers are somewhat more uniform in flow, but in these localities the drainage area is quite flat and the soil very porous so that possibly the regularity of the streams may be almost entirely due to this cause. We know that in these northern woods, swamps are numerous, as well as lakes, and that due to this fact a large quantity of water is lost through evaporation.

Deforestation does not necessarily mean the creation of a desert, but in many cases the land is either cultivated or allowed to go back into forest. Certainly a thick young forest is as efficient for flood prevention as is an old growth.

So far as the writer knows, no experimental data have been compiled showing the difference between the moisture-holding powers of an acre of forest and an acre of grain. This is therefore a matter of judgment, and the writer, for one, honestly believes that cultivation improves the moisture-holding power of the soil beyond what it was when forested. That is the object of cultivation and the success of the farmer depends on it. The growing crop also shades the ground and tends to prevent evaporation.

The farmer drains every swampy place and by so doing causes the excess of rainfall to pass quickly into the larger ditches and thence on to the river. Here is the true cause of the increased flood periods if there is an increase. It is not due to deforestation at all (as far as it is possible to prove) but to the reclaiming of every bog and shallow lake (just what the Government is now doing as fast as it can raise revenue to pay the costs), to the building of cities with their great sewerage systems, to the improvement of our public highways, etc., etc. In fact, every farmer and citizen is working toward the end that there shall be no swamps or other unhealthful wet places, and yet a commission attempts to go on record as having proved beyond all question ("in addition to proving beyond all controversy the increase in floods due to deforestation"), that the whole cause is deforestation.

Based on the generally and recently promulgated teachings the effect of forests is as follows:

(1) Evaporation is reduced.

(2) The soil is covered with a moisture-retaining mulch which not only retains moisture but causes a slower movement of the precipitation toward and into the stream.

(3) That the result of (1) and (2) is to lessen the *height* of the flood, and increase the duration, or in Fig. 1, the base a, c.

The diagrams prepared by the Commission show that this period, a, c, has increased. Therefore their proof disproves their assumption or deduction that the cause is deforestation.

It is also to be observed that even judged by the few diagrams given by the Commission, the increase in flood duration is not large. In fact, the difference in methods of gaging streams in the last ten or fifteen years might account for this. The selection of the "flood level" might also make the difference. Thus, suppose that the flow of the stream had been made quite uniform by the creation of reservoirs, as has been the case on the Connecticut, the conditions might still be such as to show an increase in flood duration below a certain flood height.

Take for example (Fig. 2) the Connecticut at Holyoke, which is one of the streams given in the report as

a proof of flood increase. At the 24th meeting of the American Society of Civil Engineers, Mr. Charles E. Chandler gave a paper on Stream Flow Data, which included among other tables one giving the flow at Holyoke for a period of 19 years. These gagings are probably the most authoritative we have for such an extended period. From this table it appears that for the first nine years the flow exceeded 6,000 sec. ft. 396 times, while for the last nine years this flow was only exceeded 357 times. This is just the reverse of the claim of the Commission, and would indicate that extended floods were decreasing. If we take only those floods equaling or exceeding 8,000 sec. ft. the proof is even more conclusive. However, if those floods equaling or exceeding 4,850 sec. ft. are taken it is found that there were 591 such floods during the first nine years of the period and 664 during the last nine years.

It will therefore be seen that it much depends on what value is considered as the flood height.

The writer has not taken the time, nor had the necessary data, to figure out the other stream diagrams given by the Commission. It is, however, admitted in the report that the basis of the calculations contains one source of error, to wit: That whereas the total rainfall for the year has been taken, only the flood-producing rains should have been allowed for. The only stream which was calculated on this basis, the Tennessee, it is admitted, disproves the theory of increasing floods. The diagram for the Monongahela indicates practically no flood increase, the difference indicated being so slight that one year of unusual drought would more than account for it. The same is true of the Savannah River. Therefore, out of nine *selected* rivers two are neutral and two show flood decrease. This is proof stated to be non-controvertible.

A slight change of climate might also account for this apparent flood increase. Suppose the summer months receive more moisture than formerly and that the heavy rains occur during a short period in the fall, then the soil being already filled with moisture sheds practically all the rainfall into the streams. Suppose the winters become more severe, and hold on till late in the spring, then there will be a prevalence of heavy spring floods caused by a sudden melting of the snows and by the Spring rains. It should, therefore, be manifest that proof of increased flood tendency should be considerably stronger than that given by the Commission before vast tracts of land valuable for farming purposes are given over to the raising of forests.

The writer believes that *the real cause is the drainage of every worthless bog into the streams.*

According to Government statistics, a forest crop should net about $3 per acre, a small part of what the land should yield, were it farmed. Forests retard civilization. Highways and railroads are seriously injured. Forest fires destroy the growth of a century and cost many lives. Then why advocate forestation? Forestation is only advisable when cultivation will not pay, and at such places only.

President Roosevelt caused to be published photographs showing the effect of erosion in China. It is true that IF the land is deforested and left alone, and IF the soil is so poor that a second growth does not soon spring up, there will be erosion, but what American farmer questions his own ability to prevent erosion on his farm? What sane man would advocate abandoning a farm to prevent erosion? Yet this is what the erosionists must contemplate as their motive in forestation and that means abandonment of the farm lands.

Conservation does not require forestation but pondage. There are few streams which cannot be partially controlled by the building of storage reservoirs. Many streams can be completely controlled and at the same time the water powers thus created made to pay an actual profit to the community. This has been demonstrated in many instances.

The writer knows from actual experience that many of our rivers are increasing in uniformity and quantity of flow. Every modern water-power development tends to improve the stream, as reservoirs are of the greatest importance to the successful working of the plant and the engineer adds as much storage capacity as possible to the pond above the dam. Municipalities are finding it necessary to build storage reservoirs for water supply. At other places large swamps are being drained for farm purposes or utilized for storage reservoirs, all of which adds to the betterment of our streams.

We must conserve our resources, but let us make sure that we are conserving rather than setting aside a large quantity of timber land for some future Congressman to confiscate.

A chapter in the Commission's report has to do with flood damages. On the face of it this compilation of flood damages would make it appear that the increase in flood damages indicated by the tables was entirely due to flood increase, a supposition as radically wrong as that of flood increase itself. In the first place, but nine years have been considered, a period of time so short as to be worthless for such a comparison. Secondly, the values assumed have been derived as follows:

The mileage involved in each yearly estimate of railroad damages has been expressed as a percentage of the total mileage for that year as given in the reports of the Interstate Commerce Commission. The several amounts were increased from the percentage that they represented to 100% to cover the entire mileage of the country.

That is, it has been assumed that the flood damage to the railroads was a criterion of all the flood damage, and that the entire flood damage for the United States was ten times that caused the railroads. This logic is at fault for two reasons. Owing to a great improvement during the last ten years in railroad accounting, a much larger annual maintenance is reported. Also, owing to the fact that where formerly railroad companies gave the streams a liberal discharge area under the bridges, they now eliminate, wherever possible, all trestles, and confine the stream to a narrow channel, thus causing the backing up of the water at flood time and the damaging of property and frequently the washing out of the tracks.

This was the case in two legal actions in which the writer acted. The Dupont Powder Co. vs. The Illinois Central, Big Four et al. was one of the cases and the case of suit brought by the farmers against C. Hoffman & Sons of Enterprise, Kan., involving the C. R. I. & P. Ry. was the second. In both of these cases the railways had eliminated long timber trestles, and in both cases great damage was caused to both the plaintiff and the defendant. This practice is general and easily accounts for largely increased damages. Again, values are increasing, and while ten years ago a railroad was valued at $35,000 per mile, it now looks cheap at double that figure. However, the table of flood damages (which does not include depreciated land values), is an eloquent plea for conservation by means of storage reservoirs, as it totals about $83,000,000 for the nine years, which capitalized at 5%, would indicate that the Government could afford to spend $1,660,000,000 for reservoirs, especially when it is certain that a part in dividends would be returned from the sale of water power thus created.

The writer does not wish to appear antagonistic to the personnel of the Commission, his thought only being that the engineering profession should criticise such reports if they appear to be inaccurate or hastily presented, and in publishing such criticisms, every opportunity is given for the proper discussion of the subject, so that if the criticism is in error, justice will be done and the correctness of the assumptions verified.

R. C. Beardsley,
Consulting Engineer.

Cleveland, O., Jan. 18, 1910.

Bonding Plaster Coatings to Concrete Interior Walls and Ceilings.

Sir: Along with many others, the writer has had some difficulty in treating the concrete surfaces left by wooden forms, so as to secure a good key for interior plastering on walls and ceilings. Any suggestions from you or any contributor to your columns regarding the best methods to pursue in securing a first-class and permanent job of plastering on concrete surfaces will be appreciated by the writer, and possibly by others who have had similar difficulties.

Respectfully,
Fred H. Fall,
U. S. Supt. of Construction.

Moscow, Idaho, Feb. 7, 1910.

[Ordinarily, interior concrete walls and ceilings are not covered with a lime-plaster coating but are either allowed to remain with the surface as it comes from the forms, or are treated by some of the numerous methods of finishing concrete surfaces, such as tooling, scrubbing, etc., and then are painted or left as they are. A cement mortar finish, sometimes termed "plastering," can be placed immediately upon a concrete surface which has been roughened either by tooling or by scrubbing and will adhere to that surface indoors where moisture and temperature ranges are not excessive, and we see no reason why a lime plaster would not adhere equally as well as mortar. If any of our readers have had any experience along this line, we will be glad to give space to any information they may have on the subject.—Ed.]

More Data as to the Cost of Factory Buildings.

Sir: Having read with considerable interest the paper by Mr. Charles T. Main on the cost of factory buildings in your issue of Jan. 27; also having designed and supervised quite a number of factory buildings myself, I am going to take issue with the statement which Mr. Main has made as to the cost of reinforced-concrete buildings, and would cite you the following instances to substantiate my claims. In all cases the designs were furnished by the writer and the building erected under his supervision.

CASE 1.—Factory building, buff brick veneer, reinforced-concrete frame; three toilet wings, iron stairwells, fire cut-offs. In fact, rather a fancy building in many ways. Cost was $1.22 per sq. ft. The floors were calculated for double the loads of those specified from Mr. Main's tables.

A plain concrete building of this size and design with a buff brick veneer, iron stairways and embellishments called for by this particular building was erected for about 90 cts. per sq. ft., including plans and specifications. The toilet equipment in this building was abnormal and is not included in the cost.

COST OF BUILDING:

Mr. Main's figures.	As specified above.	Plain reinforced concrete.
93 cts.	$1.22	90 cts.

CASE 2.—Plain reinforced-concrete building 60 ft. by 64 ft., three stories and a basement, basement windows kalamein frames and wire glass.

COST OF BUILDING:

Mr. Main's figures.	Building as erected.
$1.18	98 cts.

CASE 3.—Specially designed building, two stories high with crane runway 35 ft. wide, two mezzanine floors 20 ft. wide, including plumbing, machinery foundations etc. Was designed under the supervision of the writer by help furnished by the owner.

COST OF BUILDING:

Mr. Main's figures.	Building as erected.
$1.12	$1.20

CASE 4.—Building 60 ft. by 107 ft., 6 stories and basement, located between two other buildings with windows on the three top stories of one end only, floor loads 125 lbs. per sq. ft.

COST OF BUILDING:

Mr. Main's figures.	Contractor's bid.
$1.12	86 cts.

In justice to Mr. Main, however, with reference to the comparison in Case 4, I would state that this bidder does not include any plumbing, but does include all stairways and entrances.

The writer's experience with mill construction buildings would correspond very closely to Mr. Main's tables except in certain sections of New England, where the cost per square foot of factory buildings has been in exceptional cases lower than Mr. Main's figures or the cost of concrete buildings.

With systematic methods and proper design of reinforced concrete and a reasonable price for broken stone and sand, there is no question but that the reinforced-concrete buildings can be erected to-day for practically the same price as the brick and wood building, under the designs outlined by Mr. Main.

Where the floor loads increase to 100 lbs. live load and upward, the concrete building can be erected every time for less money than the brick and wood or the wood and steel building.

Further, the omission of every other column in the reinforced-concrete building gives much more available working floor space than where the columns are spaced 8 or 10 ft. apart, as is customary in mill construction. About the most economical bay for a concrete building is about 16 ft. by 20 ft. This gives sufficient amount of concrete in the floors to absorb vibration and make a remarkably stiff building. Yours very truly,

F. A. Waldron,
Industrial Engineer.

37 Wall St., New York, Feb. 14, 1910.

Clear Lake Dam and Reservoir, U. S. Reclamation Service, Oregon.

Sir: I note in your issue of Feb. 3, 1910, a mistake in a statement regarding the Klamath Project of the U. S. Reclamation Service.

On page 151, under the heading "Clear Lake Dam," you state that the reservoir has a surface area of about 25,000 acres, and a capacity of 1,089,000,000 cu. ft. As a matter of fact, the surface area is 24,600 acres, and the estimated capacity is 460,000 acre-feet, or almost exactly 20,000,000,000 cu. ft.

In addition to the dam, two small dikes of earth, faced with rock, are required to stop gaps in the southerly rim of the reservoir area. The dam and dikes, together, cost about $125,000.

The reservoir formed by the Clear Lake Dam and dikes shuts off one of the main sources of supply to Tule Lake. Tule Lake is a lake having no known outlet excepting for a small amount of seepage through cracks in the lava forming the southerly shore. It has a water area, at present, of about 94,000 acres, and the surface has risen about 14 ft. in the last 50 years. It is expected that the storage and increased evaporation in Clear Lake Reservoir, taken in connection with the construction of other works to be undertaken in the near future, will result in a gradual lowering of the surface of Tule Lake, and the uncovering, eventually, of many thousand acres of high-grade agricultural lands.

Yours respectfully,
W. W. Patch,
Project Engineer, U. S. Reclamation Service.

Klamath Falls, Wash., Feb. 9, 1910.

Civic Service on the Part of College Faculty Members in Small Towns.

Sir: An editorial note in your issue of Feb. 3, 1910, drew deserved attention to the responsibility of members of faculties of colleges to take an active interest in matters affecting the public welfare. You surmise truly that the faculty of Dartmouth College has not failed in that respect, but it may add point to your remarks to specify some of the public services rendered by college men here.

A professor of civil engineering has served as Chairman of the Board of Precinct Commissioners about 15 years, having charge of highway improvements and construction of macadam roads. This office includes duty as health officer. A professor of mathematics has served many years as Justice of the Police Court, and one term in the state legislature. A number of professors in various departments, and the wife of one professor, have served terms of ten or more years as members of the School Board. A professor of chemistry has been presiding officer at town meetings during several years. Another professor of civil engineering has been Engineer and President of the Water-Works Co., a semi-public corporation, more than 15 years; also member of the State Board of Health for about the same period.

A member of the faculty of the medical college has the widest sphere of activity. As medical director of the college he has oversight of the sanitary condition of 17 dormitories, all of the eating clubs and the "commons"; makes frequent inspections and tests of food supplies; checks epidemics of influenza by prompt fumigation of recitation rooms and affected dormitories; usually has personal knowledge of any serious illness among more than a thousand students; makes frequent observations and tests of the bacteriological and other conditions of the water in the large storage reservoir which supplies both the college and town; and, as bacteriologist of the State Board of Health, has the resources of the laboratory and expert knowledge at command for the benefit of the community. His prompt recognition and treatment of first cases has, without doubt, averted local epidemics of contagious diseases.

A large part of these various services are rendered either gratuitously, or for small pay in no wise commensurate with their value to the public. And why not? True public spirit cannot be measured by a dollar standard. John Smeaton, the first English "civil engineer," only gave expression to a sentiment exemplified in many lands by true men of every age when he put forth the maxim: "The abilities of the individual are a debt which he owes to the common stock of the public happiness." College men, above most others, have exceptional opportunities for gaining knowledge and culture. If they would escape the reproach of possessing only "ineffective culture," which is sometimes thrown at them, let them find some way to discharge loyally their obligation to serve their fellow men and "lend a hand" where it is needed.

Respectfully yours,

Robert Fletcher,

Director Thayer School of Civil Engineering.

Hanover, N. H., Feb. 11, 1910.

Concerning the Formulas for Computing Stresses in the Manhattan Bridge.

Sir: The following comments relate to the suspension bridge formulas derived by Prof. Turneaure, contained in Mr. Ralph Modjeski's report on the Manhattan Bridge [Eng. News, Oct. 14, 1909, pp. 401-408]. The writer had occasion to check over these formulas and a number of typographical errors were found in them as printed in Engineering News, and these are listed below.

The formulas given by Prof. Turneaure employ the assumption originally made in designing the bridge, that the dead load is uniform and equal on main span and side spans. On this assumption the parabolas of the two spans had the same parameter. In checking up the weights from the actual design, however, it was found that the dead-load weights in the side spans were somewhat in excess of that of the main span. On account of the heavier load in the side spans it became necessary to decrease the parameter for the land-span cables in order to avoid strain on the stiffening trusses under dead-load. The decrease in the parameter also equalizes the horizontal pull on the towers under dead load. The parameter in the main span might have been increased and the suspenders lengthened, but this would have meant greater tension in the cables. Reducing the paramater in the land spans reduces the dead-load tension in the cables, with the net result in all spans that the strain on the cables is actually less than at first intended. This reduction of parameter, giving a drop of cables of nearly 2 ft. at the land-span centers, moves the vertices of the initial land-span parabolas from a point over 87 ft. beyond the panel point "O" to a point about 65 ft. beyond this panel point.

That is to say, in the assumptions s_0 for the land spans is greater than s_0 for the main span, consequently s_1 for the land spans is greater than s_1 for the main span. The average value of s_1 has been assumed as approximately equal to

$$\frac{8f}{l^2}\left(H_t+\frac{1}{2}H\right)$$

This is the average value of s_1 for the main span; the average value of s_1 for the side spans, similarly, equals

$$\frac{8f_1}{l_1^2}\left(H_t+\frac{1}{2}H\right)$$

The left member of equation (8), which represents the work done by vertical displacement, will then be

$$\frac{8f}{l^2}\left(H_t+\frac{1}{2}H\right)\int\eta\,dx + \frac{8f_1}{l_1^2}\left(H_t+\frac{1}{2}H\right)\left[\int\eta_1\,dx+\int\eta_2\,dx\right],$$

where η_1 and η_2 refer to the two side spans.

The solution of equation (8) now gives the general expression

$$H=\frac{\int_0^l\left(M_0-\frac{p}{c^2}\right)dx+\frac{\pi}{\pi'}\begin{bmatrix}\text{terms}\\ \text{for side}\\ \text{spans}\end{bmatrix}+\frac{l^2\,w\,t}{8f}\int\frac{d\,s^2}{d\,x}}{-\left[\int_0^l\left(C_1e^{cx}+C_2e^{-cx}\right)dx-\frac{2}{3}f\,l+\frac{8f}{c^2\,l}\right]-\frac{\pi}{\pi'}\begin{bmatrix}\text{terms}\\ \text{for side}\\ \text{spans}\end{bmatrix}+\frac{H+H_t}{FE}\frac{l^2}{8f}\int\frac{d\,s^3}{dx^2}+\frac{l^2\,wt}{8f}\int\frac{d\,s^2}{d\,x}}$$

where π/π' is the ratio of the parameters of main and side-span cables. The temperature term is negative in the numerator and positive in the denominator for high temperatures, and vice versa for low temperatures.

In the full expression for the denominator D of the various formulas for H, the term π/π' occurs as a factor in all land-span terms, *i. e.*, the fourth, fifth and sixth terms. The constants C_1 and C_2 remain unaffected by this factor; but in the values for H it appears in the side-span terms of the numerators as follows:

1. Case II., 3d and 4th terms.
2. Case IV., 2d and 4th terms.
3. V., 1st and 2d terms.
4. VI., 2d and 4th terms.
5. VII., 1st and 2d terms.
6. VIII., 2d, 4th, 5th and 6th terms.

Taking the constants as used by Prof. Turneaure in his calculations, we have,

$$\pi=\frac{l^2}{8f}=\frac{1446.7^2}{8.145.3}=1800.5$$

$$\pi'=\frac{l_1^2}{8f_1}=\frac{713.5^2}{8.37.2}=1710.6$$

In other words, the land-span terms should be increased by 5¼%. This increase will affect the final results differently for different loadings; but in any case the change in the final results will not be of any great consequence. However, when the various land-span terms have been evaluated for any particular loading, it is such an easy matter to apply the factor that it might as well be done.

The typographical errors in the formulas, most of which, however, are not very serious, are as shown in the table at the foot of this page.

As assistant to Holton D. Robinson, Chief Engineer of the Glyndon Contracting Co., erectors of the Manhattan Bridge cables, the writer had been entrusted with the full responsibility for the correct alinement of the cables. To get these placed as accurately as possible it was necessary to know very nearly what should be the alinement of the foot-bridge cables. The first foot-bridge cable was taken across the towers and adjusted on June 15, 1908, eleven days after the new information on the dead-load weights had come into possession of the contractors. The new information necessitated revised computations for determining the alinement of the foot-bridge cables.

John Berg.

2 Rector St., New York City, Jan. 4, 1910.

THE PRODUCTION OF ASBESTOS in Canada reached a total valuation of about $2,600,000 in 1908, according to a bulletin on "Asbestos" issued by the Canadian Department of Mines, Ottawa, Ont. Next to coal, asbestos is "now one of the most important of non-metallic mineral products of Canada, and supplies a very large proportion of the world's demand."

1.	In value of	D, p. 407,	$\int\frac{d\,s^3}{d\,x}$	should read	$\int\frac{d\,s^3}{d\,x^2}$
2.	" "	D, p. 407,	$\frac{l^2\,c^2\,I\,L_s}{8\,f\,F\,c}$	" "	$\frac{l^2\,c^2\,I\,L_s}{8\,f\,F}$
3.	" "	L, p. 408,	$\frac{l_1^2}{16\,f_1}+$	" "	$\frac{l_1^2}{16\,f_1}\times$
4.	" "	C_2, Case I,	$\frac{1}{c^2}\left(\frac{P}{H}-\frac{8f}{l^2}\right)$	" "	$\frac{1}{c^2}\left(\frac{p}{H}-\frac{8f}{l^2}\right)$
5.	" "	H, Case II,	$\frac{P}{c^3(e^{cl}-e^{-cl})}$	" "	$\frac{p}{c^3\,(e^{cl}-e^{-cl})}$
6.	" "	H, Case II,	$C_1{}^3\,(e^{c_1l_1}+1)$	" "	$c_1{}^3\,(e^{c_1l_1}+1)$
7.	" "	C_1, Case II,	$(1-e^{-cl})$	" "	$(1-e^{cl})$
8.	" "	H, Case III,	$-e^{c(l-k)}$	" "	$-e^{-c(l-k)}$
9.	" "	H, Case III,	$\frac{l^2\,L+w\,t\,H_t}{8f}$	" "	$\frac{l^2\,L_1\,w\,t\,H_t}{8f}$
10.	" "	C_2, Case IV,	$\frac{p}{2\,H\,c_2}$	" "	$\frac{p}{2\,H\,c^2}$
11.	" "	H, Case V,	$\frac{l^2\,L_1}{8f}\,w\,t\,H_t$	" "	$\frac{l^2\,L_1}{8f}\,w\,t\,H_t$
12.	" "	C_2, Case VII,	$\frac{1}{c_1^2}\left(\frac{p}{H}+\frac{8f_1}{l_1^2}\right)$	" "	$\frac{1}{c_1^2}\left(\frac{p}{H}-\frac{8f_1}{l_1^2}\right)$
13.	" "	C_1, Case VIII,	$\frac{8f_1}{c_1^2\,l^2}\left(1-e^{-c_1l_1}\right)$	" "	$\frac{8f_1}{c_1^2\,l_1^2}\left(1-e^{-c_1l_1}\right)$
14.	" "	C_2 Case VIII,	$-c_1$	" "	$-C_1$

An Experimental Road Surfacing of 2-in. Concrete Cubes.*

By J. Y. McCLINTOCK† and GEORGE C. WRIGHT.‡

This paper is in the nature of a description of a system of road surfacing which is, we think, new in this country, and is taken in the main from a report of Mr. McClintock, made to the Highway Commission of New York State.

Macadam used to say that if one could get stone broken into cubes of uniform size of about 2 ins. and once get them laid the ideal road would be secured. The increasing difficulty of maintaining a macadam surface composed of irregular shaped fragments of varying size under the conditions of rapidly moving motor vehicles emphasizes the importance of the remark of the father of stone roads.

The general use of Portland cement for most purposes of construction naturally leads to the thought of the possibility of taking stones as they come from the crusher in irregular shapes and square them up by means of Portland cement. The low price at which Portland cement can be secured brings the cost of such treatment within reason. It appeared probable that if the wearing surface of a highway could consist of 2-in. cubes placed closely together and made of either Portland cement with gravel or broken stone, or vitrified shale, or asphaltic concrete, or bitulithic concrete, or iron furnace slag, that the following results might be obtained: Comparative freedom from dust, smoothness of surface, good footing for horses and wheels, pliability permitting of changes in the base due to freezing and thawing, and movement due to the contraction and expansion.

As these cubes could be supported on any suitable local stone or gravel the cost per mile for first-class road would evidently be very much below that of ordinary paving brick and more lasting than any of the asphaltic or bitulithic mixtures, and further, the maintenance would be simplified and reduced in cost.

The State Highway Commission authorized the expenditure of $2,250 for the purpose of making a preliminary demonstration, with the following results: On the Ridge Road northwest of the city of Rochester, N. Y., the original trap rock surface 2 ins. thick was worn completely off at the center and nearly so at the sides of the 16-ft. macadam roadway, leaving exposed a good solid lower course of rather large size broken Medina sandstone, resting on a good gravelly foundation.

The existing surface was somewhat rough and knobby, and over this was spread as thin a layer as possible of screened gravel, which was rolled down with a 12-ton roller, so that in spots it was 2 ins. thick and in other spaces over the knobs it was of no measureable thickness. The resulting surface had a crown of about 4 ins. in 16-ft. width. On this bed so prepared was placed directly a wearing coat of 2-in. cubes for a width of 15 ft., being laid close together by hand, with the edges held up temporarily by 2-in. planks laid lengthwise with the road. On the cubes was spread a small amount of fine, somewhat loamy gravel, which was broomed in, after which the heavy roller was slowly passed over the whole of the surface, forcing the cubes to take a full bearing on the supporting gravel. The edges and roller wheel was supported by the planks, then the side-planks were pulled up and moved ahead and coarse gravel ¾-in. to 1¼-in. in size was placed along the sides next to the cubes on the shoulder for a width of about 2 ft. Outside of this a finer gravel was spread, feathered off to a width of about 3 ft., more of the fine loamy gravel was spread on the top and broomed and flushed in until the space between the cubes was thoroughly filled, the gravel on the shoulders was wet and the whole surface thoroughly rolled with the heavy roller.

A stretch of road 1,800 ft. long was surfaced with cubes. On 1,600 ft., Portland cement gravel concrete cubes were used, on 200 ft. vitrified shale cubes 2¼ ins. in size were used. For a length of 100 ft. a concrete sunken curb 6 × 9 ins. in dimension was used in place of the gravel shoulders. On 100 ft. in length the joints between the cubes were filled with Portland cement grout instead of the fine loamy gravel. For 60 ft. on which the joints were filled with the fine gravel, and light asphaltic road oil was sprinkled over.

A machine for making cubes which is an adaptation of the ordinary cement brick machine was furnished. This machine made 68 cubes at one operation, resting on a wooden tray, and the tray was carefully placed on a drying rack without disturbing the freshly made cubes. The cubes remained in racks 24 hrs. and were then dumped in a pile. This pile was thoroughly sprinkled twice each day.

The number of cubes made was about 7,000 upon the first day, but within a few days the same gang was able to make with ease 26,000 of the cubes. Various sizes of screens were tried from ½ to 2-in., but it was found that the ½-in. screen gave a product that could best be handled in the machine. Experience showed that the concrete had to be rather dry in order to avoid settling and bulging of the cubes before the concrete set. Seven men and a foreman did all the work. The amount of cement used averaged 2.2 bbls. to a cu. yd. of concrete. The area covered with cement cubes was 2,652 sq. yds., upon which was laid all of the 730,000 cubes manufactured, except about 5,000 kept for repairs. The cost of cement cubes laid was as follows:

Cement, 0.88 bbls.	$0.121
Cost of factory	0.107
Labor of manufacture	0.161
Gravel, 50c. per cu. yd.	0.024
Carting	0.027
Laying	0.072
Total cost per sq. yd. laid	$0.512

There was placed on shoulders 219 cu. yds. of gravel covering 1,800 sq. yds. costing $2.12 per cu. yd. rolled in place, or 26 cts. per sq. yd.

In considering these figures as the basis for estimating cost it is obvious that there might be reductions made in cost of cement by using a reduced quantity, and in reduced cost of carting, the cost of the factory might be distributed over many more square yards, the cost of labor by use of concrete mixer and other labor-saving devices, the cost of gravel in pit is usually nearer 10 cts. per cu. yd. than 50 cts., which was paid here. The cost of laying was very much reduced as the men became experienced, and this could be still further reduced by paying for it on the basis of piece work.

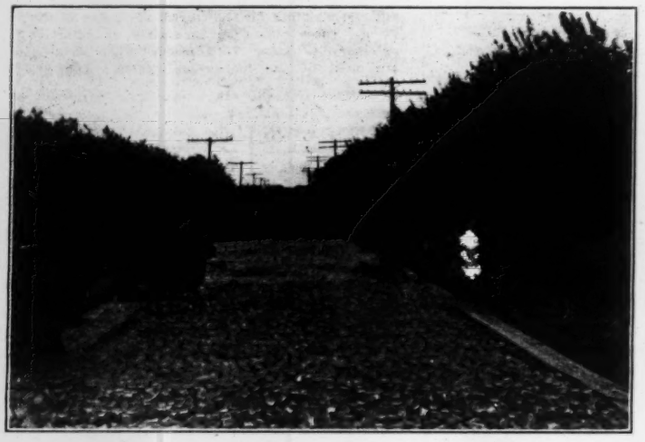


FIG. 1. VIEW OF 2-IN. CONCRETE CUBES ON EXPERIMENTAL ROAD.

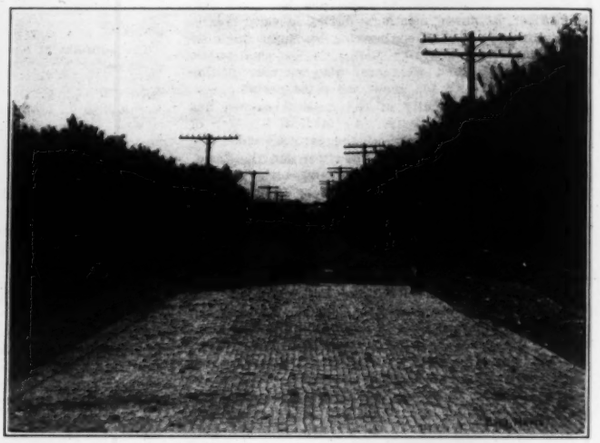


FIG. 2. CUBES IN PLACE ON ROAD.

*Paper presented at the Annual Meeting of the National Association of Cement Users, Chicago, Ill., Feb. 21-26, 1910.

†County Engineer, Monroe Co., N. Y.

‡Consulting Engineer, Rochester, N. Y.

Convention for Standardizing Specifications for Paving.

A convention of city engineers and municipal officials was held in Chicago Feb. 21 to 26 to consider means for standardizing specifications and contracts for paving work and paving materials, and to effect a permanent organization for this purpose. The convention was called by Mayor Busse, of Chicago, who sent requests to the mayors of a number of cities to appoint delegates. About 40 cities were represented, and the meetings were held at the La Salle Hotel.

The first general meeting was held on Feb. 21 at which addresses were made by Mayor Busse and by Mr. Frank T. Fowler, temporary chairman. The latter pointed out that the work of the association should result in a better control of contract work, with consequent improvement in quality and economy; also in a saving to the tax payer, a better character of maintenance, a reduction in the delays in obtaining material, a better knowledge of the cost of work, and greater uniformity in specifications and methods. A number of committees were then appointed, most of which were to prepare and present specifications (which could be adopted as standard) for various kinds of paving. Several meetings were to have been held for the discussion of these reports and specifications, but owing to the time necessarily required by the committees for their work most of these meetings were abandoned and only two general meetings were held, the first on Feb. 24 and the second on Feb. 25.

The committee reports were passed with but little discussion, and a considerable part of the time of the meetings was occupied in organizing an association and in routine business. It was manifestly impossible for committees to prepare in such a brief time standard specifications which would be uniformly applicable and acceptable, but the technical features undoubtedly will receive greater attention at future meetings. The report of most interest was that of the Committee on Bonds and Guarantees, which recommended that contractors be required to deposit with the city authorities a cash reserve to defray the cost of repairs and maintenance during the guarantee period. The discussion upon this report showed strong objections to the practice of simply requiring the contractor to give bond for the maintenance of the paving laid by him. The reason assigned was the failure of the bonding companies to satisfactorily fulfil the requirements and their frequent evasion of their responsibilities. If the companies will decide upon some uniform system which will afford real protection to the city's interests, this system may be adopted, but in general the cash reserve system is considered preferable. It appeared that in many cities the majority of cases brought against bonding companies result in the companies escaping the responsibility.

A permanent organization was effected under the name of "the Organization for Standardizing Paving Specifications." The membership is by cities, with dues of $100 per year for cities of over 100,000 population and $50 per year for those of less population. The dues for Associate Members, (consulting engineers, supply men, etc.) will be $200 per year. The next meeting will be held at New York in 1911. The officers for the first year are as follows: President, Frank T. Fowler (Superintendent of Streets), Chicago; Vice-Presidents, Geo. W. Tillson, M. Am. Soc.

C. E., Chief Engineer of Bureau of Highways, New York, N. Y.; W. J. Hardee, M. Am. Soc. C. E., City Engineer, New Orleans, La.; L. W. Rundlett, M. Am. Soc. C. E., Commissioner of Public Works, St. Paul, Minn.; Geo. W. Craig, M. Am. Soc. C. E., City Engineer, Omaha, Neb. Secretary and Treasurer, John B. Hittell, M. Am. Soc. C. E., Chief Engineer of Streets (Board of Local Improvements), Chicago.

Annual Convention of the National Association of Cement Users.

The sixth annual convention of the National Association of Cement Users was held in Chicago, Ill., Feb. 21-25, 1910, in conjunction with the regular annual Cement Show that has been held in that city for some years past. In the past conventions of the Association it has been customary to have exhibitions of cement and concrete products and machinery and the necessity of arranging for two exhibits, one at the Chicago Cement Show and one at the convention, has naturally led many of the exhibitors to reduce the elaborateness of their exhibits at either or both places. This year, however, the joining of the two enabled the manufacturers to concentrate their efforts on the one exhibition with a naturally gratifying result, both as to the quality of the exhibits and the number in attendance thereon.

The large exhibition also brought to the convention a much greater number of members than ever before. The registration at the convention proper was close to 400, about one-half of the total membership, and there were in attendance a number of others who were not registered. The out-of-town attendance on both show and convention, as measured by the reduced-ticket validation, reached nearly 2,000.

The meetings of the Association are divided into three kinds, the reading and discussion of technical papers, the discussion and adoption for letter ballot of so-called specifications prepared and submitted to the Association by special committees, and the general discussion of special subjects such as sidewalks, cement products, reinforced concrete, etc., in sections, this latter taking place in the morning from 9 to 10.30 before the opening of the regular meetings. Profiting by the experiences of the last two years, when the programs were so long as to require many extra meetings of wearisome length, the management endeavored this year to reduce the scheduled events to specified lengths that could be adhered to. This was accomplished with more than the ordinary success, but, nevertheless, it was found necessary on two of the five days to hold three sessions, one each in the morning, afternoon and evening. The program was lightened, however, by a more-or-less non-technical and patriotic session on the evening of Washington's Birthday, Feb. 22.

Committee Reports and Specifications.

By far the greatest interest taken by the members in attendance on the convention was in the reports of the Committees and the Specifications that these committees presented for approval. Three committees, those on Art and Architecture, Concrete and Reinforced Concrete, and Machinery and Appliances, presented merely progress reports. Two committees, Building Laws and Insurance and Exterior Treatment of Concrete Surfaces submitted valuable reports, but no specifications. The committee on Specifications for Fireproofing gave an abstract of its plan for future work. The remaining committees, those on Roadways, Sidewalks and Floors and Specifications for Cement Products presented five so-called specifications which were the basis of the most vigorous discussion and argument of the whole six days' sessions.

It is understood by all those interested that one of the primary objects of the National Association of Cement Users should be to standardize the practice of concrete construction, but it is not so generally understood that no society or group of men can standardize an industry unless the actual work done in that industry somewhat approaches a standard. The mere setting forth of certain rules and regulations and calling them "Specifications" cannot make all the workers follow such rules unless they are in approximate accord with the methods those workers have been following. The concrete industry, as an industry, is new and many and varied ways there are of performing the details connected with it. It has been the task of the Association to collate and examine these various methods and in the light of the best experience to recommend certain standards. Necessarily these recommended standards have agreed with the practice of only a portion of the members of the Association, and those with whose practice they have not agreed each year make strenuous objections to any such standards being adopted. The methods and practices being also in a state of change, it has been found each year that the standards adopted the year before have to be changed to meet the new requirements.

With these two facts before it, it would seem that the Association is taking the wrong method of bringing about the desired standardization. This method is the one common in technical societies in the preparation of specifications; that is, a committee is appointed which prepares a specification and that specification is then presented before the annual meeting of the Association, there to be fought over and changed, according to a majority vote of the members present. The changed document is then submitted to letter ballot, and becomes an accepted specification if less than 10% of the total membership vote against it. In actual practice this results in a carefully constructed specification prepared by an expert committee being ripped up and changed at short notice on the floor of the convention, where a majority vote can be obtained on almost any change, provided the proposer has a plausible tongue. The result is a hodge-podge of a specification, which does not satisfy and which has to be changed the ensuing year.

It was obvious to any one who sat through the specification debates at Chicago last week, that the list of standards proposed by the committees were not "Specifications," which should be rigid and unchanging and not affected by minor variations of practice or preference, but that they were rather "Recommended Practice," or the best ideas that could be formulated concerning the present stage of a changing industry. It is not time yet to make rigid specifications on concrete work. When a body of trained concrete workers and expert concrete designers fight for three hours over details of aggregate, base and sub-base and expansion joints of concrete sidewalks, and finally adopt a "specification" many of whose clauses have been written on the floor and adopted immediately thereafter, the product of such a conference cannot be called a "specification" and submitted to the engineers and contractors of the country as absolute. At best, it cannot be more than "Recommended Practice" to be followed wherever possible.

The five "Specifications" submitted by the committees were for (1) Portland cement sidewalks, which, although adopted by letter-ballot last year was chopped into a different document this year; (2) concrete street pavements; (3) Portland cement curb and gutters; (4) architectural concrete blocks, and (5) plain concrete drain tile. Of these the first three were adopted, as described above, and sent to letter ballot; the fourth was only submitted as a suggestion and was so received and returned to the committee, and the last—that on drain tile—was fought over for some hours, returned to the committee with a recommendation that a conference be held with the drain-tile manufacturers, then sitting in convention in Chicago. This conference was held and a compromise reached, and the new "specification" again brought before the convention, but opposition was again very strong and the whole thing was rejected and sent back to the committee. The main objection to this last revision was that it entered too largely into the matter of manufacture, which, according to the opposition, is not the purpose of a specification.

Until these specifications are passed by letter ballot it does not seem desirable to comment upon them.

The "Proposed Standard Building Regulations for the Use of Reinforced Concrete" which were returned to the committee last year for revision, were adopted, after some changes, and referred to letter ballot. The changes made on the floor were few, relating mainly to clauses which would allow the use of re-rolled rails provided the metal so obtained passed the other tests required. It is not expected that these regulations will be adopted in toto by cities or states, but that they will be used as a standard toward which building departments may work and also as standards for the smaller communities where there is not enough expert official advice to formulate laws.

BUILDING LAWS AND INSURANCE. — The Committee on Building Laws and Insurance (Mr. W. H. Ham, Chairman), has prepared an especially valuable report, in two parts, one on each of the subheads of which it treats. The portion on insurance includes a number of tables of rates on concrete buildings compiled from data submitted to the committee. In this connection the report reads:

> The Association has now on file a list of about 1,000 concrete buildings, and has written the owners requesting information, as per an insurance information blank. Replies have been received covering about 300 buildings, of which 255 contain complete information. This represents quite an increase over the number of replies received last year. It will be noticed that there are no rates of insurance given for cement hollow block buildings. The members of this association who are interested in the matter of rates for cement hollow block buildings have been repeatedly requested during the year and also at the annual convention to send in the names of the owners of such buildings in their territory and the failure of the committee to secure rates is due to the failure of these members to respond to the committee's request. The committee would again make an appeal for information as to the name and address of the owners of cement hollow block buildings in order that they may secure rates for this class of buildings.
>
> Special attention is called to the fact that the information the committee has collated shows that 26.6% of the buildings covered by replies are not insured by the owners, the type of construction being each case considered sufficiently fireproof as to render insurance unnecessary. Some owners even do not consider it necessary to insure the contents of their buildings, because either the contents are not likely to be destroyed by fire, or the fire could be confined to one room, or in some cases, because the insurance companies specify prohibitive rates due to the inflammable character of the contents. The committee has been advised by several owners that they have had a fire in one room of their building and that the same was confined to that room. The owners claim that the loss sustained in such cases would be a great deal less than the premiums required to carry insurance.

The portion of the report on Building Laws contains a large tabulated statement of the building laws as regards concrete in the largest cities of the country. As a concise exposition of current practice it is extremely useful. This report also contains extracts from various building codes in relation to the design of hooped columns.

EXTERIOR TREATMENT OF CONCRETE.—This committee (Mr. L. C. Wason, Chairman) has prepared a most extensive report upon the various methods for finishing a concrete surface. From the portions read by the chairman we would judge that it will be the most complete study of this matter ever made. The material is not yet entirely collated and so is not available for publication.

Papers.

A great number of papers presented before the meetings were of an extremely interesting character and too long to abstract in this account of the convention. These we will publish as separate in this or some later issue, but for the benefit of those who may wish to send to the association for the papers when published, we give at the end of this section a complete list of all the papers not abstracted here.

CONCRETE ROADWAYS.—Mr. Frank R. Charles, City Engineer of Richmond, Ind., where, as is well known, a great number of concrete roadways have been laid, read a paper entitled "Development of Concrete Road Construction." In addition to a short description of the construction, which is generally a 1:2:5 base 5 ins. thick, with 1-in. 1:2 surface, the main point of the paper related to joints and corrugations and read as follows:

> Our experience seems to show that blocks [cut with tool after the pavement is laid as a monolith.—Ed.] should be as large as possible in order to reduce the

number of joints, and that the joints should be as thin as can be made. On the other hand, we find that blocks 10 to 25 ft. square are about as large as can be made in our climate without developing temperature cracks. These latter, however, apparently do not injure the pavement, beyond detracting from its appearance, as cracks that have existed for years show no enlarging. . . . . Corrugating or grooving the surface is also objectionable for the same reason as are the joints [that is, they chip and space under the horses' hoofs.—Ed.] Also, the grooves catch and collect the dirt, interfering with the cleanliness of the pavement and rendering it more difficult to sweep. Possibly the corrugations afford a slightly better foothold for the horses, but I think even here the advantage is exaggerated.

Mr. Charles did not give any data as to amount of traffic on the roadways or as to the feeling of the owners of horses in regard to it.

DAMPPROOFING CONCRETE.—A paper on "Dampproofing Concrete Structures Without Altering Their Appearance," was read by Mr. C. M. Chapman of the Westinghouse, Church, Kerr & Co. It outlined in a general manner some tests made by that company

to find a material, which, applied to the surface of a structure already completed, whose walls were of such porosity as to absorb water during rain sufficient to dampen the interior of the walls, would render that outer surface dampproof without materially altering the natural color or appearance of the concrete blocks or monolith.

These tests consisted in observing the time taken for water filling a 40 cu. cm. depression in the upper face of an extremely porous 3 in. concrete cube to soak entirely into the cube, the bottom of the depression being coated with the dampproofing material under test. A number of patented products were excluded because of their discoloring nature, but tests were made on 19 different compounds, not named in the paper. The tests so far have been on cubes filled immediately after the coating dried and on the same cubes after being exposed some months to the weather. In no case has the test been at all satisfactory, for after being exposed to the weather only one of the compounds dampproofed the surface sufficiently to hold the water in the depression for the space of one day.

It should be noted that the tests were exceptionally severe, in that the unprotected concrete blocks were very porous and absorbed water greedily. Moreover, the compounds were allowed to soak thoroughly into the top surface and two coats were always applied.

The tests are still in progress and further reports are expected in the future.

CEMENT AS A REINFORCEMENT FOR COLUMNS.—The principle has been enunciated by several writers that the cheapest reinforcement for a concrete column is additional cement, and it has been shown in some few experiments that the cost of enough cement to produce a richer and consequently stronger mixture is less than the cost of sufficient steel, either longitudinal or hooping, to increase the strength of a column a similar amount. This principle was again restated and partially proved in a paper by Mr. Peter Gillespie, Lecturer, University of Toronto. Mr. Gillespie started out with a selected list of longitudinally reinforced-concrete columns (mixtures varying from 1:1:2 to 1:3:6, but mostly 1:2:4) in which it was shown that the average steel stress was 6,000 lbs. per sq. in. and the average concrete stress, 530 lbs. per sq. in. This latter value is about as high as such concrete can be safely stressed, while the steel is at least only about one-half of its safe allowable value, a very uneconomical distribution, although the steel area percentage varied from 0.97 to 2.09%, which are near the standard percentages used.

He then had tests made on a 1:1 concrete of hard trap rock well graded from ¼ to ¾-in. in size. This concrete showed a crushing strength of about 5,300 lbs. per sq. in. With such a concrete a number of columns were longitudinally reinforced with from 0.88 to 4.42% of steel and tested. These columns showed a steel working stress of 10,400 lbs. to a simultaneous concrete stress of 1,250 lbs. per sq. in. Now this latter is a perfectly safe load to put on a 5,300 lb. concrete, but it will be noticed that the steel is much nearer its safe stress and that the materials are in much better balance than in the first-rated columns. It was also shown that the set in the latter columns was much less than in the former.

In further tests Mr. Gillespie endeavored to find by experiment and theory the amount of Poisson's ratio in hooped columns made of this strong 1:1 concrete, and with hooping varying from 2.4 to 5.7% in section. As a result he decided that this ratio is about ¼ in the cases tested. With this as a basis he computes that the stress in bands is only about twice that in the enclosed concrete, or for a 500-lb. concrete, each sq. in. of hooping steel takes only 7,000 lbs. per sq. in.

Finally, the paper gives comparative costs for a column to bear a given load for three different kinds of columns. (1) steel protected by concrete, (2) 1:2:4 concrete with 1% of longitudinal steel and (3) 1:1 concrete with ½% of longitudinal steel. The respective costs per unit were $6.63, $3.01 and $1.62 and the respective cross-sectional areas, 1.8, 6.3 and 2.8 sq. ft. It must be noted, however, that the use of such high stresses in the 1:1 concrete will often reduce the section to so small an area that it will exceed the safe $\frac{l}{r}$ ratio in columns, in which case this enconomy does not exist.

LONGITUDINAL REINFORCEMENT IN COLUMNS.—A paper with the above title by Mr. Sanford E. Thompson continued the discussion in columns. This maintained that "the occasional criticisms that vertical bars do not add to the strength of the column are absolutely unfounded by either theory or fact." Theoretically a longitudinal steel bar embedded in a concrete column must either shorten with that column and hence take its percentage of the load or it must slip or buckle. Manifestly it cannot buckle when surrounded by concrete, and if butted on the ends or provided with sufficient length to assure a proper bonding strength they cannot slip. Therefore, they must take load. This is borne out in all tests on such columns known to the author. A longitudinally reinforced concrete column always shows a strength greater than a plain column of equal section and often greater than the theoretical amount figured in giving the steel its proper proportion of the load.

CONCRETE BLOCKS AND TILE.—There were three papers of interest to the tile and block manufacturers entitled, respectively, "Cost and Advantages of Concrete Drain Tile," by J. H. Libberton; "Essentials in Cement Hollow Block Construction," by Ernest B. McCready and "Installation and Operation of a Steam Curing Plant," by F. S. Phipps. The first described in some detail a method of card indexing the work of a drain tile plant, so that an idea could be had as to the exact costs of all parts of the work. It also showed a method of testing drain tile adopted by the Universal Portland Cement Co. This consists in bedding the tile for its upper and lower sectional thirds in plaster of paris and then crushing it between the jaws of a compression machine. The second paper merely emphasized the necessity for a better inspection and selection of the material that goes into concrete blocks and advised more care to be used in their manufacture.

The third paper described a steam-curing plant in which the steam chambers are made of concrete blocks. The chambers are fed wet steam from a boiler used only for that purpose; they can hold two carloads of blocks at once. In connection with steam curing of concrete blocks two things were emphasized. First, it is absolutely necessary that the steam be wet, or else the block will be burned and the concrete will not properly set. One member advocated the passing of the steam through a water bath to ensure this wetness. The other point is that the blocks should be run into the steam bath immediately after leaving the molds and not allowed to set for any length of time. This has proved to bring about more rapid curing.

SEPARATELY-MOLDED MEMBERS. — Mr. Charles D. Watson in a paper under the above title compared the in-place method of construction with the erection of factory-made units, as follows:

The principal advantages of the unit system over the monolithic field method, besides the absence of all form work, are—

First—Speed of erection.

Second—Reliability and uniformity of strength; especially so when the members are made in a factory where the proportions of material can be kept theoretically correct, and where they can be tested before being placed in the work.

Third—Economy of concrete and consequent reduction of dead weight made possible by more economical shape of members, and by the fact that larger working factors for strength of concrete in compression can be used on account of the superiority of the material.

Fourth—Facility with which future alteration can be made.

About the only advantage the monolithic system has over the unit is its enormous rigidity, and a slight economy of steel required for reinforcement, due to continuous beams. In tall separately molded unit structures rigidity at least equal to the present frame construction can be obtained by proper design of the reinforcing cement of the supporting frame.

In addition he gave a number of illustrations of such work and some figures as to costs, which latter he is not ready just yet to give out for publication. When they have been revised he will do so.

CONCRETE HOUSES.—Mr. Milton O. Morrill, an architect from Washington, D. C., read a paper entitled "Inexpensive Houses of Reinforced-Concrete," illustrated with a number of designs which he has developed. Mr. Morrill has been working for some years past on the design of cheap, small dwellings of reinforced concrete which would be much cleaner, more sanitary and fireproof than the frame or brick house of the same cost. The designs which he showed were admirable in two respects, they were remarkably artistic and they were along lines especially adapted for concrete.

In one respect, however, Mr. Morrill's plans are open to criticism and that is in their estimated cost. He said that he expected to be able to build six and seven room houses of concrete at a cost of from $200 to $300 a room. This low cost is to be obtained by the use of a cheap low grade of materials in the concrete aggregate and by the successive use of some metal forms which he has designed. These forms are of thin sheet metal in lengths and heights approximately equal to those of ordinary large building stone and they are to be used many times on the same building by removing from below where a wall has set and placing above at the top of the wall. Experience has shown that the reuse of such forms cannot be continued for a great number of times, because of the abuse and excessive use soon causes the forms to wear out. The burden of proof is, then, on Mr. Morrill. Until he tries out these forms in a number of buildings his cost figures will be subject to doubt. The use of low-grade materials for walls is to be criticized, also, especially as solid walls are to be used. With poor materials the tendency to porosity is very great and the question of waterproofing becomes important.

Mr. Morrill's plans are among the best of the class to which they belong as architectural possibilities. It remains to be seen where their economical and structural value is.

OTHER PAPERS.—The following papers were read, but are too lengthy or important to be abstracted here. "Laying Concrete Under Water, Detroit River Tunnel," by Olaf Hoff; "Comparative Value and Cost of the Groined Arch in Large Reservoirs," T. H. Wiggin; "Proposed Method for the Reinforcement of Concrete Compression Members," Robert A. Cummings; "A Simple Method for Computing the Strength of Flat Reinforced-Concrete Plates," Angus B. MacMillan; "Long Span Light Floor Reinforced-Concrete Construction," Emile G. Perrot; "Concrete for Maritime Structures," Chandler Davis; "Preservation of Timber Piles with Concrete Where Exposed to Sea Water," C. C. Horton; "Experiments on the Effect of Sea Water on the Tensile Strength of Various Mixtures of Cement and Sand;" C. M. Chapman.

Two illustrated lectures were presented in the course of the convention, one by Pres. Richard L. Humphrey, as a presidential address, upon the developments of concrete work in Europe, as noticed by the lecturer on a recent visit abroad. The other lecture was by Mr. R. S. Greenman,

Resident Engineer, Office of State Engineer and Surveyor, upon "Application of Concrete in Barge Canal Work." Each of these lectures was illustrated with a magnificent set of views.

The officers for the ensuing year are to be: Pres., Mr. Richard L. Humphreys; 1st Vice-Pres., Mr. Edward D. Boyer; 2d Vice-Pres., Mr. M. S. Daniels; 3d Vice-Pres., Mr. E. S. Larned; 4th Vice-Pres., Mr. F. A. Norris, Treas., Mr. H. C. Turner. The secretary is yet to be selected. It was stated that the Association is growing rapidly, but that the expenses are increasing at a greater rate so that it is necessary that more members be procured in order to continue the present high standards of the society as to publications, etc. To this end an ordered campaign for new members is to be carried on during the ensuing year.

The Efficiency and Cost of Concrete for the Preservation of Piles Exposed in Sea Water.*

By C. C. HORTON†.

It has long been the aim of engineers and builders to find some method of treating or protecting wooden piles or other wood structures from the destructive attack of marine borers. Many methods have been tried, and success more or less marked has attended some of them, the principal methods being the chemical treatment of the wood fiber and the mechanical protection of the pile or timber by a protective covering of metal, treated wood or concrete. However, we are only interested in the application of concrete or cement and will pass over the other methods.

There are quite a variety and several classes of concrete covering of wooden piles, and we will endeavor to describe several, which are more or less practical. We will classify them "A," "B," "C" and "D," merely to distinguish them and not according to their relative merits.

CLASS "A."—A wooden pile covered with a jacket of concrete, made by placing a mold around the pile and filling with concrete—reinforced with steel or not, as desired—applied before driving. This makes a pile that can be inspected without trouble, but has the drawback of being heavy and difficult to handle and drive. Also it will sink, presenting the same difficulty as a solid concrete pile in this respect. Furthermore, the same precaution must be observed in driving it as in the purely concrete pile. It is difficult to give exact costs as these will vary with the size of the pile, the length covered on each, the varying cost of materials, the proportion used in the concrete, the use or omission of reinforcing, cost of labor, etc. We will endeavor, however, to give a relative cost of the several methods, so that a comparison of the various classes may be made.

CLASS "B."—This class includes piles covered after they have been driven and before the superstructure has been built. The covering is applied by lowering over the pile a continuous concrete wood or steel jacket, so proportioned as to leave an annular space between the pile and jacket of from two to four inches, preferably the latter; this space being then pumped out and filled with concrete.

This method presents some difficulties where deep water is encountered, due to the liability of the jacket to collapse, if built of wood or steel. Furthermore, it is difficult to exclude mud and water if the sea bottom is soft or if the casing is not perfectly tight. It is sometimes found necessary to seal the bottom with cement and allow it to set before pumping out the annular space. This should be as complete as possible for the best results.

CLASS "C."—This is a modification of class "B" in that it uses the same type of jacket, with the exception that it is made sectional and in two parts to admit of its application to wharves already built or where the superstructure is in place.

A tile jacket is sometimes used in addition to the others of class "B." The jacket is applied by placing the sections around the pile and lowering section by section, by suitable means, until the submerged portion of the pile is covered and sufficient penetration is obtained into the sea water; the annular space is then filled with concrete without first pumping out the sea water. With this style of construction it is impossible to exclude the water and mud, which is a serious drawback. The concrete is liable to be of inferior quality, especially at the bottom, the mud line—the very point that should be made the most impregnable—being the principal point of attack of that most destructive of wood borers, the teredo.

CLASS "D."—This is a class distinctly by itself and is of more recent origin than any of the previously described methods of armoring. It consists of a light steel sectional jacket, fitted at the bottom with a self-adjusting diaphragm, made to accommodate itself to the irregularities of the pile. The method of procedure is to fit the bottom section containing the diaphragm around the pile and fill with concrete, the section being suspended from above by suitable means, usually by winches. The first section is then lowered sufficiently to permit the addition of another section, which is filled with concrete: this is repeated until the submerged portion of the pile is covered and the desired penetration is obtained into the sea bottom. The annular space between the pile and the jacket should be at least four inches, and in large piles of say 18 to 20 ins. the jacket should be five or six inches.

This method renders the concreting of piles very simple and effective and obviates the principal difficulties of the three other classes of covering. It is especially adapted to the repair of old wharves, badly eaten with either the teredo, or limnoria. The San Francisco Harbor Board has adopted this latter method for the repair of their old wharves, and finds it economical, easily applied and durable. Classes "A" and "B" are not suitable for the repair of old wharves, the expense being prohibitive. Between class "C" and "D" the latter may be applied for approximately 20% less per lin. ft. than the former.

For new work, classes "A," "B" and "C" would cost approximately the same, with a slight possible advantage in favor of class "A." Class "D" may be applied to new construction more cheaply than on repair work, and would run 20 to 25% cheaper than any of the other methods.

The San Francisco Harbor Board is paying $1.55 per ft. for class "D" work on all sizes of piles. This includes profit and royalty, the actual cost ranging from $1.00 to $1.25 per lin. ft.

*Paper read before the Annual Convention of the National Association of Cement Users, Chicago, Ill., Feb. 21-25, 1910.

†Healy-Tibbits Construction Company, San Francisco, Cal.

Barges of Concrete to Be Built at Panama.*

Work will be commenced shortly on the construction of three concrete barges, to be used in supporting the dredging pumps for the hydraulic excavating and pumping plant of the Pacific Division. They will be built near the site of the hydraulic pumping station at a point on the Canal, nearly opposite Gorgal.

While the construction of barges from concrete is not a new idea, its adaptation is not known to have hitherto been attempted in American engineering. Concrete barges have been successfully used in Italy during the past few years, and recently the use of this material in the construction of floating craft in that country was extended to the building of transfer boats, a type of vessel similar to the New York car ferries. The plans of the Pacific Division barges contain numerous modifications from the Italian type, some to meet local conditions, and some, because of the continual improvement in concrete construction methods.

Each of the Pacific Division barges will be 64 ft. long by 24 ft. wide, and will have a depth of 5 ft. 8 ins. The interior beams and columns will have a spacing of 10 ft. longitudinally and 8 ft. transversely. Wooden forms will be used in their construction and the barges will be launched sidewise. Two interior longitudinal walls will extend throughout, with a bulkhead at each end, forming an interior compartment 40 ft. long by 8 ft. wide. The interior form work will be built in collapsible sections, so that the latter can be removed readily as the work advances. The frames for the hull will be constructed first, and the preliminary work will consist of the erection of supports on which wooden forms will be placed.

The wall construction will consist of one layer of ½-in. mesh No. 12 wire cloth; ½-in. transverse rods placed 8 in. c. to c., and ½-in. longitudinal rods spaced 12 in. c. to c., all securely fastened to the reinforced concrete framework described above. The side walls and bottom of the barge will then be formed by laying on several coats of plaster made of portland cement mortar, and troweled down to a hard surface. The plaster will be laid on first from the outside, and an additional coat laid on from the inside, so as to thoroughly cover the ½-in. mesh and steel rods.

The deck of the barge will consist of concrete slabs 3½ in. thick, having spans of 10 ft. in length and 8 ft. in width, reinforced with ½-in. rods, both longitudinally and transversely. Wells are provided for pumping.

The dredging pump, motor and equipment, weighing approximately 60,000 lbs., will be located near the middle of the barge. The maximum draft of the barges, when loaded, will be about 3 ft. They can be moved readily from one place to another in the channel, and each will be equipped with four mooring bits situated a few feet back from each corner, secured to the barge by long bolts imbedded in the concrete of the side columns and diagonals.

The barges will be erected on cribbing built for the purpose, and launched from ways, on the west bank of the basin, a short distance south of the Miraflores lock site.

*From the "Canal Record," Feb. 9.

A Controllable Discharge Bucket.

The controllable-discharge bucket shown in the accompanying view is one that has recently been devised by Mr. A. N. Doud to be used more especially in concrete work between narrow forms where it is desirable to regulate the size of opening so as to keep the wet mix from spilling or splashing outside of the forms. Its design is evident from the cut. It will be noted that the control gates are segmental, sliding along a similar segment on the bottom of the bucket and are controlled through a pivoted set of levers to

A Controllable-Discharge Bucket.

the outside lever. These pin joints form better wearing parts than a sliding bar arrangement found on some buckets. The bottom of the slides are provided with flanges which form a stand on which the bucket can rest when closed. This type is also made with a car-truck base, which can be run on tracks and through the bottom of which the dump may be made into forms placed below the tracks. This has been used to great advantage in concrete-making yards in the pouring of separately molded members of slender shape, such as piles, columns, etc.

The same company, the Acme Equipment & Engineering Co., also makes a square-bottomed center-dump bucket which has a similar opening mechanism, that is, a three-pin lever controlling the two bottom halves of the bucket.

HYDRAULIC FILL OF GATUN DAM.—The surface of the hydraulic fill in the east half of Gatun Dam is at 40 ft. above sea level. From this time forth the filling will advance with greater rapidity than for some months past, because the three 20-in. suction dredges which are pumping sandy clay into the dam will be assisted by three 20-in. relay pumps. Two of the dredges are pumping material from the flats north of the dam, and the relay pumps to assist them are erected on the north toe. The third dredge is pumping from the river bottom, south of the dam,, and the pump to assist it is installed on the south toe.

One of the relay pumps was put in operation on Jan. 23, another on Jan. 30, and the third will be at work in a few days. They are 20-in. centrifugal pumps, each direct-connected to a 550-HP. induction motor run by current generated at the Gatun power plant. These pumps are necessary because the suction dredges were designed to operate against a head, including friction, of only 75 ft., whereas the total load has been over 100 ft. with consequent reduction in the output of the dredges. The friction in the pipe lines has been equivalent to a 2 or 2½-ft. lift per 100 ft. of pipe, and the length of the pipe lines has run from 2,000 to 4,500 ft. The actual lift has been as high as 45 ft. above sea level. The relay pumps are installed at such elevations and distances as to take an average of about one-half the load until it becomes necessary to install additional relays for the higher elevations of the dam, which is to be built to 115 ft. above sea level.

The hydraulic fill is held in position by two mounds of rock and earth, and the water that flows off after the material has been deposited is drained through these mounds, or toes, in 20-in. pipes.—"Canal Record," Feb. 9.

Changing an Interurban Electric Railway from Alternating to Direct-Current Operation.*

In accordance with announcements made late in 1909, the Washington, Baltimore & Annapolis Electric Ry., changed its operating system from 6,600-volt, single-phase to 1,200-volt, direct-current. The proposal to abandon single-phase operation has attracted widespread attention, though the change was made advisable wholly by local conditions. The beginning of single-phase operation was noted in an article in Engineering News, describing the general features of the road, Vol. Jan.-June, 1908, p. 195. It will be recalled that the cars for this line were unusually heavy (109,000 lbs. on the track), and were barred from entering the heart of Washington, owing to the limited strength of the conduit yokes, supporting the city tracks. It was necessary to use on these tracks, cars of no more than 40 tons weight.

As the operation of the road continued the commercial advantages of running the cars to a convenient point in Washington increased and the company was forced to solve the problem of securing a 40-ton car with power enough to maintain the high-speed service undertaken. A minor contributing cause of the change in operating system was the heavy cost of inspection and maintenance of the complicated car equipment, needed for running on single-phase and direct-current grounded lines and on a direct-current ungrounded line.

An investigation of the engineering features involved by these requirements led the company to adopt a 1,200-volt, direct-current system as best meeting the several requirements. A contract was made thereupon with the General Electric Co., of Schenectady, N. Y., which furnished the single-phase electric equipment of the road. By the contract this concern was to provide and install the necessary equipment for cars and substations. The Cleveland Construction Co., was retained as consulting engineers and to supervise changes in transmission system, overhead construction and substation buildings. All these contracts were made with the understanding that the regular service of the road should not be interfered with.

The change was actually made without any accidents or delays. At 1.15 a. m., on the morning of Feb. 15, the last alternating-current car was taken off, and at 5.20 a. m., the first direct-current car was started. During the first day of operation the cars ran over 4,500 car miles and not a trip of the regular schedule was lost. A saving of some 25% in power was indicated by the wattmeter records of the first few days.

From the previous article in Engineering News, noted above, it will be seen that for operation as a single-phase railway, power was purchased from the Potomac Power Co., in Washington and delivered to the railway's substation at Bennings, being received through underground cables at a potential of 6,600 volts and a frequency of 25 cycles. It was there changed to two-phase, T-connected transformers giving 6,600 volts on one phase and 33,000 volts on the other. The 6,600-volt phase furnished power directly to the trolley for operating between the District line and Naval Academy Junction. For the operation of the sections of the line from Naval Academy Junction to Baltimore, to Annapolis and to Annapolis Junction, power was transmitted, single phase, at a potential of 33,000 volts to the substation at Naval Academy Junction, where it was stepped down to 6,600 volts and fed to the trolley lines. At Naval Academy Junction, 6,600-volt, two-phase, synchronous motor-generator sets, in duplicate, supplied 600-volt direct current for the car barns and yard. At Baltimore and Annapolis, the 600-volt direct-current local trolleys were supplied with power by means of single-phase motor-generator sets, taking power from the high-tension trolley.

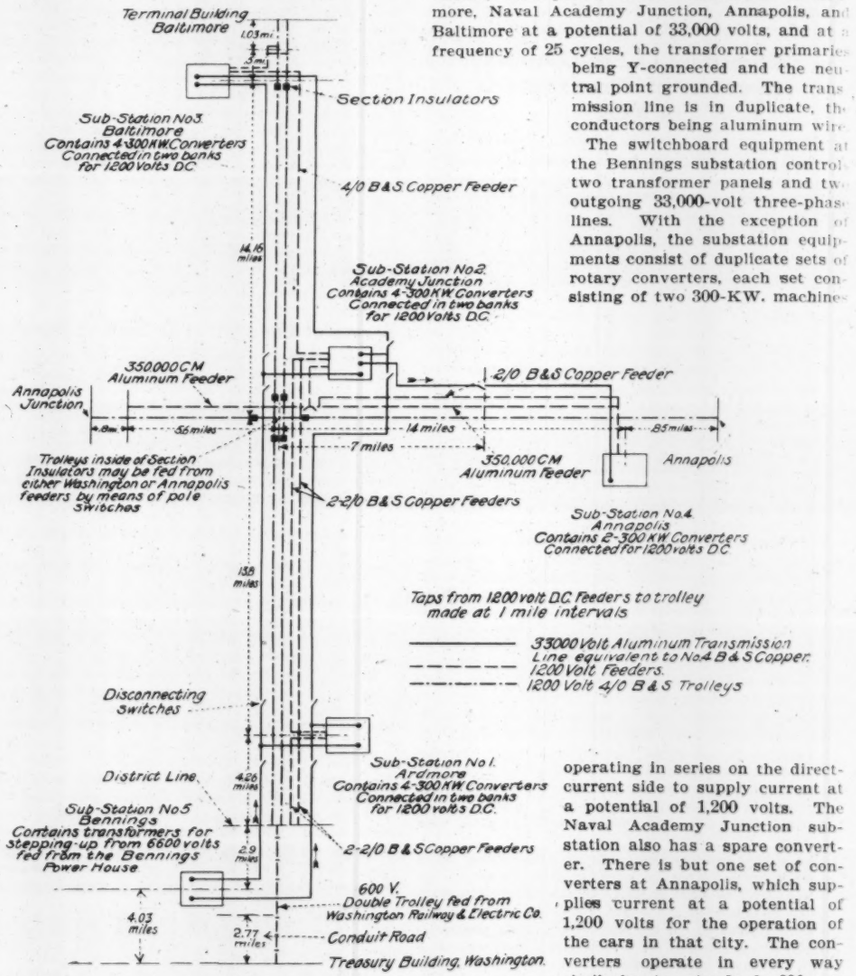
The overhead line was of a single catenary type hung from brackets.

In changing over the system, since it was necessary to move the motor-generator sets, the transformers, and the switchboards out of the substations without interfering with the operation of the road, one of the motor-generator sets and its controlling panel at Baltimore was moved into a temporary structure, made by laying galvanized iron sheets on a timber frame. It was necessary that the set should be out of service the shortest time. So after preparations were completed, in the early morning, the set was jacked up by means of four 20-ton jacks, rollers were placed underneath, and it was pulled into position in the temporary substation by means of a block and tackle. The switchboard panel and other necessary apparatus was then transferred and installed. At midday the installation was complete and the set was then started up and operated in multiple with the set in the substation for two days as an assurance that the temporary installation would afford reliable service. Then the second set in the substation was shut down and moved to the temporary building. Such changes as were necessary in order to prepare the old substation for the new apparatus were rushed to completion and the apparatus was installed. In the meantime the same plan of work had been followed with regard to the other substations, and the three transformers at Bennings had been rewound. It was also necessary to install a 1,200-volt generating system, and to put it into operation on an experimental track in order that the direct-current cars might be tested out and the car crews broken in to their use. This ensured that the car crews would handle the cars under the new system with as great dispatch as under the old and would have no difficulty in maintaining the schedule.

In the old system, the trolley wires for the two tracks were insulated from one another, while in the new system they are cross connected. The jumper cables for this purpose and also those between the 1,200-volt feeders and trolleys were all connected in during the period required for shutting down the alternating-current system and starting up the 1,200-volt.

The general scheme of the 1,200-volt system is shown in the figure. It should be noted that in this diagram complete circuits are indicated by single lines. Power is purchased from the Potomac Power Co., and received as before, at the Bennings substation where it is stopped up and transmitted, three-phase, to the substations at Ardmore, Naval Academy Junction, Annapolis, and Baltimore at a potential of 33,000 volts, and at a frequency of 25 cycles, the transformer primaries being Y-connected and the neutral point grounded. The transmission line is in duplicate, the conductors being aluminum wire.

The switchboard equipment at the Bennings substation controls two transformer panels and two outgoing 33,000-volt three-phase lines. With the exception of Annapolis, the substation equipments consist of duplicate sets of rotary converters, each set consisting of two 300-KW. machines operating in series on the direct-current side to supply current at a potential of 1,200 volts. The Naval Academy Junction substation also has a spare converter. There is but one set of converters at Annapolis, which supplies current at a potential of 1,200 volts for the operation of the cars in that city. The converters operate in every way similarly to standard 600-volt machines, being started with open fields from half-voltage taps on the transformer secondaries in the usual manner.


Terminal Building Baltimore
1.03 mi.
.5 mi.
Section Insulators
Sub-Station No.3 Baltimore Contains 4-300 KW Converters Connected in two banks for 1200 Volts D.C.
4/0 B&S Copper Feeder
14.16 miles
Sub-Station No.2 Academy Junction Contains 4-300 KW Converters Connected in two banks for 1200 Volts D.C.
350000 C.M. Aluminum Feeder
2/0 B&S Copper Feeder
Annapolis Junction
.8 mi.
5.6 miles
1.4 miles
8.5 miles
7 miles
350,000 C.M. Aluminum Feeder
Annapolis
Trolleys inside of Section Insulators may be fed from either Washington or Annapolis feeders by means of pole Switches
2-2/0 B&S Copper Feeders
Sub-Station No.4 Annapolis Contains 2-300 KW Converters Connected for 1200 volts D.C.
13.8 miles
Taps from 1200 volt D.C. feeders to trolley made at 1 mile intervals
33000 Volt Aluminum Transmission Line equivalent to No.4 B&S Copper.
1200 Volt Feeders.
1200 Volt 4/0 B&S Trolleys
Disconnecting Switches
District Line
4.26 miles
Sub-Station No.1 Ardmore Contains 4-300 KW Converters Connected in two banks for 1200 volts D.C.
Sub-Station No.5 Bennings Contains transformers for stepping up from 6600 volts fed from the Bennings Power House
2.9 miles
2-2/0 B&S Copper Feeders
600 V. Double Trolley fed from Washington Railway & Electric Co.
4.03 miles
2.77 miles
Conduit Road
Treasury Building, Washington.

ELECTRICAL SYSTEM OF THE WASHINGTON, BALTIMORE AND ANNAPOLIS ELECTRIC RY., AS CHANGED FROM 6,600-VOLT SINGLE-PHASE TO 12,000-VOLT DIRECT-CURRENT.

Power may be supplied to three sections of the trolley line from the Academy Junction substation. The 33,000-volt transmission line to the Annapolis substation is controlled at the Academy Junction switchboard. This substation also has one 600-volt direct-current circuit for the operation of the motors in the repair shops. The Baltimore substation supplies current at 600 volts to the overhead lines in Baltimore before the junction with the United Railways Co. over whose tracks they run to a terminal station. In Annapolis the 1,200-volt overhead system is permitted within the city limits. At the Washington end of the road, the grounded 1,200-volt system stops at the District line. From here the tracks and power of the Washington Railway & Electric Co., are used. This system has a 600-volt double, overhead trolley to H and Fifteenth Sts. N. E. and from these has a contact-rail conduit.

*From information furnished by the General Electric Co., Schenectady, N. Y., and by the Washington, Baltimore & Annapolis Ry. Co.

For the general protection of the power apparatus, 33,000-volt aluminum-cell lightning arresters are being installed in all substations. Each transmission line is protected by an overhead ground wire.

The rolling stock consists of 30 passenger cars and three service cars. Each passenger car is equipped with four 75 HP., 600/1,200-volt, commutating-pole motors and each service car with four 140-HP., 600/1,200-volt, motors, also having commutating poles. The cars are equipped with automatic, relay-type multiple-unit control with jumper connection boxes for operation in trains, if desired. A potential of 600 volts, for controlling and lighting the cars while running on the 1,200-volt lines, is obtained by means of a dynamotor. On the 600-volt sections the control and lighting circuits are supplied directly from the trolley. The cars are equipped with automatic straight air brakes with graduated release and with air compressors operated by 1,200-volt motors.

It has been noted that these cars are required to operate at various times on 1,200-volt, single trolley with ground return, on 600-volt, double overhead trolley with metallic circuit, and on 600-volt slotted-conduit system. The ground connection for single-trolley operation is obtained by means of a connection through the negative trolleys and their holding down hooks, so that when either negative trolley is raised for operation on the double overhead trolley section the ground circuit is broken. The change from over-head, double trolley to conduit is made by double-pole, double-throw, transfer switch which may be operated either from the motorman's cab, by compressed air, or by hand.

A LARGE CIRCULAR SAW BURST Feb. 23 in the Newark plant of the Carnegie Steel Works. Three workmen were struck by pieces of the saw and one was killed instantly while the others were badly injured.

THE U. S. TUG "NINA" has been given up as lost by the naval authorities. She has been missing since Feb. 6, when she sailed from Norfolk, Va., bound for Boston, Mass. The tug left Norfolk with 32 seamen on board and no trace of the vessel itself or any of the men has been found since.

A STORM ON GREAT SALT LAKE Feb. 14 considerably damaged the roadbed of the Western Pacific Ry. where it crosses the shallow southern arm of the lake. The ties were undermined for long distances and at other points the track was buried under sand. Train service was interrupted for several days.

SNOW SLIDES IN NORTHERN IDAHO on Feb. 27 and 28 destroyed three small mining towns. The greater part of the town of Burke was buried under 50 ft. of snow and earth. Carbonate, Hill and Mace, both within a few miles of Burke, were the other towns affected. In these three towns, more than 30 persons are known to have been killed and about as many others were buried for some time in the snow before being rescued. The unusual violence and extent of these slides in the Coeur d'Alene district is ascribed to the record-breaking depth of snow in the mountains.

An avalanche of snow on the western slope of the Cascade Mts. in central Washington, March 1, overwhelmed two trains and seven locomotives, four of which were electric, at the mouth of the Great Northern Ry.'s Cascade Tunnel. Twenty persons are reported killed. The wrecked train was one bound from Spokane to Seattle which had been stalled in the mountains for four or five days. Press reports state that the power-house which supplies current for the electric locomotives used in the tunnel was carried away, together with a railway depot and water tank.

A SERIOUS GAS EXPLOSION occurred in a residence in Montclair, N. J., on Feb. 25. A gas range in the kitchen of the residence was being used for baking. The gas was turned on, but for some reason was not ignited, and the failure to ignite was not noticed until the gas had been escaping for a half-hour or so. Most of the gas which escaped passed into the chimney through a vent flue, and appears to have formed an explosive mixture in the flue. There was probably also a considerable amount of gas in the upper part of the room near the ceiling. This mixture of gas and air was eventually fired, whether from the burning pilot light or from a stove in the laundry beneath is not known. The explosion completely wrecked the chimney and blew out a side and end of the room. A range boiler in the kitchen, which was heated from a laundry stove, appears to have been filled with water considerably above the boiling point at the time, and the shock of the other explosion, with the release of steam from the broken pipes, caused this to explode soon after the gas explosion. Of three persons in the kitchen, one was fatally injured and two others received serious hurts.

A FIRE PANIC at a moving-picture show in Trujillo, Peru, on Feb. 23, is reported to have killed some 50 persons.

Crowding at a moving-picture show in Patton, Pa., caused the collapse of the floor, on Feb. 19. The floor was only about 5 ft. above ground, and no one was killed, though many were injured. Fire from overturned stoves was put out in time.

THE STRANG GAS-ELECTRIC MOTOR CAR, "Irene," equipped with the suction oil-gas producer known as the "hydrocarbon converter" and described in Engineering News, Feb. 24, made trial trips to Lakewood, N. J., over the tracks of the Central R. R. of New Jersey on Feb. 22 and March 1. Petroleum residue, between kerosene and the lubricating oils and known as "scalp" or "solar" oil was used. The fuel consumption while operating this car, equipped with 150 HP. engines, on gasoline is claimed to be about 0.60-gal. per car-mile over good tracks with only slight grades, while the fuel consumption on gasified petroleum residue is stated to be only about 0.29-gal. per car-mile. On account of the difference in cost per gallon, the cost of fuel with petroleum residue is about one-eighth that with gasoline.

The occasion of these demonstration trips to Lakewood was the formal launching of the Hydro-Carbon Company by Mr. Thomas A. Nevins (of Thos. Nevins and Son, Bankers, at 37 Wall St., New York City). This company will manufacture this oil-gas producer in forms to furnish gases adapted variously for light, heat and power.

A NEW SUBWAY IN NEW YORK CITY, the Broadway-Lexington Ave., or Triborough route, is to be put under contract for construction within two or three months. It will give (1) a second complete north-south line through Manhattan borough, with two branches reaching out into Bronx borough to near the northern limit of the city, one northward and one northeastward; (2) a line across the East River to Brooklyn borough, there utilizing the Fourth Avenue Subway, now under construction, and extending southerly to Fort Hamilton and southeasterly to Coney Island; and (3) a short loop route through Brooklyn connecting with the Fourth Avenue subway and by way of the Williamsburgh Bridge, utilizing the Center St. loop subway (Manhattan) just built but not yet used.

The Manhattan portion of this system extends from the Harlem River south on Lexington Avenue and its prolongation, Irving Place, to 14th St., thence south largely under private property into Broadway at about Ninth St., southerly along Broadway to Vesey St., west to Church St., and southerly to the Battery. All of this line, possibly excepting a short length at the southerly end, will be four-track, with a terminal loop either at the Battery or near the City Hall. The four tracks comprise two local tracks and two express tracks. A novelty is introduced on most of the length in the shape of double-deck arrangement, the local tracks occupying the upper level and the express tracks the lower level. This is desirable because Broadway and Lexington Ave. are rather narrow, so that the width of structure needed for accommodating four tracks on one level would come too close to the buildings. The doubledecking begins on Broadway at Houston St. and extends to 103d St. on Lexington Ave.; again at 113th St., continuing to the Harlem River. It affords the great advantage that where, as in the northerly half of the line, the street profile is undulating, the express tracks can keep on a flat grade between express stations (about 1 mi. apart), while the local tracks follow the surface grades, the two coming together at express stations.

The Bronx section of the system, connecting by tunnel under the Harlem River about on line of Lexington Ave. near 131st St. with the Manhattan line, extends from Pelham Bay Park southwesterly on Westchester Ave., Southern Boulevard and 138th St. to Park Ave., where connection is made with the tunnel; and from Jerome Ave. and Woodlawn Road, near the northern limits of the city, southerly on Jerome Ave., River Ave., East 157th St. and Mott Ave. to a junction with the tunnel at the same point as the Westchester Ave. line. Both branches will be three-track, and a large part of each will be on elevated structure, the eastern branch north of Whitlock Ave. and the Jerome Ave. branch north of 157th St.

The Manhattan-Brooklyn part of the line consists of a four-track crosstown subway in Canal St. (Manhattan), having a terminal loop near West St., and running easterly in Canal St., rising to the surface and crossing the Manhattan Bridge, dropping into subway in Flatbush Ave. Extension (Brooklyn) and extending southerly on Fourth Ave. (the Fourth Ave. line now being built) to 42d St. (the end of the present contracts), thence continuing southerly in three-track subway to Fort Hamilton on the Narrows; and also branching off the Fourth Ave. line at 40th St. (Brooklyn) easterly and southerly via 40th St., New Utrecht Ave., 86th St. and Stillwell Ave. to a loop terminus on Surf Ave., Coney Island. Of this Coney Island branch a considerable part will be on elevated structure.

The Broadway-Lafayette loop in Brooklyn, utilizing the Center St. loop subway recently built, extends from a terminal near Manhattan end of the Brooklyn Bridge northerly through Center St., easterly through Delancey St., rising to the surface and crossing the Williamsburgh Bridge, and thence southeasterly in subway through Broadway (Brooklyn), returning by Stuyvesant Ave. and Lafayette Ave. to a connection with the Fourth Ave. line. The exact traffic relation of this loop line to the Manhattan-Brooklyn or Fourth Ave. line has not been determined but it may be operated for the present as an independent loop and is important as a foundation for a future line east through Brooklyn to East New York.

This system is made up of parts of half a dozen different routes among fifteen or more laid out in 1905 and 1906 by the Rapid Transit Commission, the predecessor of the present Public Service Commission, described (with map) in our issue of Dec. 27, 1906, p. 681. The system now decided on is, however, an integral and coherent one, and there is full agreement between the Public Service Commission and the Mayor and other members of the new city administration to put it under construction as soon as possible. The engineering department of the Commission has been working on detail plans for a long time past, and is nearly ready. As soon as detail plans and specifications are completed, bids will be called for. Present indications are that the system will be let for bidding in numerous sections, each under option for either construction bid alone or combined construction and operating bid.

THE FREIGHT CAR SURPLUS has begun to decrease somewhat, as is normal for this part of the year, the records for 1908 and 1909 showing a decrease of 50,000 cars in the surplus between the first of January and the middle of March. The last report of the American Railway Association, for Feb. 16, shows a net increase of 10,000 cars demanded, made up of 6,000 decrease in surplus and 5,600 increase in reported shortages. The remaining surplus was 45,513, with countervailing shortages aggregating 31,204. A year ago there was a surplus of 301,000 cars, while in February, 1908, the surplus was somewhat larger, about 320,000 cars.

THE AMERICAN RAILWAY ASSOCIATION has amended the per diem rate charged for the use of freight cars in interchange, to 30 cts. per day during the period from March 1 to Aug. 1, and 35 cts. during the remainder of the year. The original per diem rate was 50 cts., but after the panic of 1907, when an enormous car surplus rolled up, the Association reduced the per diem charge 25 cts. This is generally conceded to be too low a rate to be influential in effecting the return of cars to their owners, and committees of the Association have been for some months working upon a plan for the amendment of the per diem charge. A letter ballot was sent out in November, in which the members voted on three different rates—30 cts., 35 cts. and 40 cts.—but neither rate secured the necessary two-thirds vote. A second letter ballot was therefore sent out, following a special meeting of the Association on Jan. 27, and the plan above set forth was adopted by the following vote: Yea, 224 members, representing 1,767,162 cars; Nay, 87 members, representing 419,851 cars.

THE CAUSES OF THE RECENT PARIS FLOOD are to be studied with a view to possible measures of prevention of similar disasters in the future. We append a brief statement regarding the proposed investigation, taken from a special dispatch to the New York "Tribune."

The commission appointed by the government to ascertain the causes of the inundations and to study means of preventing them began work yesterday at the Ministry of the Interior, under the direction of Premier Briand. The president of the commission is Alfred Picard, who has organized it into nineteen sub-commissions, each with full powers to deal with its own special task. The prevailing opinion among the members of the commission favors the creation of a series of reservoirs for the surplus waters of the Seine both above and below Paris. M. Daubrée, director of the departments of Waters and Forests, who is chairman of the sub-commission to find out the relation of the destruction of trees to floods, thinks that, owing to the peculiar constitution of the soil in the plateaus of the affluents of the Seine, wholesale tree cutting is a principal cause of the recent flood.

THE PENNSYLVANIA RAILROAD SYSTEM in 1909 earned on all its lines a total of $315,400,804, an increase of $38,626,489 over 1908 and only about $11,000,000 less than the earnings for the boom year of 1907. The net earnings of the system were $86,263,212, an increase of $14,870,985 over 1908 and of some $3,000,000 over 1907. The income from other sources gave the system a total gross income over operating expenses of $113,520,505, an increase of $14,269,597 over 1908 and of about one million dollars over 1907. The company's annual report

states that the total expenditure on the new passenger terminal in New York City and the tunnel lines leading to it is $102,495,530, but the extension is appraised at only $57,495,000 on the company's books, the remaining cost having been charged to the profit and loss account. The terminal is expected to be in operation before the close of the coming summer. During the coming year, work is to be pushed on relief lines or additional tracks to accommodate the traffic on crowded sections. The construction of elevated tracks through Rahway, N. J., is to be one of the first tasks undertaken.

Personals.

Mr. G. Hamilton Holmes has opened an office for general engineering practice at 78 Patton Ave., Asheville, N. C.

Mr. Normand W. Mohr has been appointed City Architect of San Francisco, Cal., to succeed Mr. Emil de Neuf, resigned.

Mr. Gerhard M. Dahl has been appointed Commissioner of Street Railways of Cleveland, Ohio, with a salary of $12,000 per year.

Mr. Chas. E. Waddell, M. Am. Soc. M. E. has opened offices for a general engineering practice at 78 Patton Ave., Asheville, N. C.

Mr. Henry R. Towne, Past-President, Am. Soc. M. E., President of the Yale & Towne Manufacturing Co., has been elected President of the Merchants' Association of New York.

Mr. Walter C. Kerr, M. Am. Soc. M. E., President of Westinghouse, Church, Kerr & Co., has been elected Third Vice-President of the Merchants' Association of New York.

Mr. Geo. F. Samuel, Assistant Engineer in the Department of Public Works, Chicago, is now Acting City Engineer in the absence of Mr. John Ericson, who has taken a leave of absence.

Mr. F. M. Falck, heretofore Division Engineer of the Philadelphia & Reading Ry. at Reading, Pa., has been appointed Assistant Superintendent of the Wilmington and Columbia division, with office at Reading, Pa.

Mr. J. M. Fitzgerald has been appointed Assistant Signal Engineer of the New York Central & Hudson River R. R. with office at Albany, N. Y., to succeed Mr. W. A. Peddle, who has resigned to enter the service of another company.

Mr. A. C. Cornelison, Superintendent of Construction, Post Headquarters at West Point, N. Y., for the past four years, has been appointed by the Panama Canal Commission to be Supervisor at Station A, Cristobal, Canal Zone.

Mr. William E. Pierce, formerly Assistant General Yardmaster of the Cincinnati, Hamilton & Dayton Ry., in Toledo, Ohio, has been appointed Superintendent of the Toledo & Western R. R., with headquarters at Sylvania, Ohio.

Mr. John M. Egan, formerly President of the Central of Georgia Ry. and later President of the Union Bridge & Terminal Railway Co., of Kansas City, Mo., has been made President of the Metropolitan Street Ry. of Kansas City, Mo.

Mr. Jas. A. Green, Assoc. M. Am. Soc. C. E., formerly with J. G. White & Co., at Richfield, Idaho, has opened offices for the practice of irrigation and hydraulic engineering and construction at 226 La Salle St, Chicago, Ill.

Mr. George A. Kyle, Assoc. M. Am. Soc. C. E., formerly Chief Engineer of the Oregon Trunk Line R. R., has been made Vice-President and General Manager to succeed Jackson Smith, whose death was noted in our issue of Feb. 17. Mr. Kyle will be succeeded as Chief Engineer by Mr. Ralph Budd, formerly Chief Engineer of the Panama R. R.

Mr. Bushrod W. Taylor, formerly Superintendent of the Louisville division of the Pennsylvania Lines west of Pittsburg, has been appointed General Agent of the same railway. He will be succeeded as Superintendent at Louisville by Mr. F. J. Kron, Superintendent at Cambridge, Ohio. Mr. Kron will be succeeded by Mr. J. C. McCullough, heretofore Trainmaster at Pittsburg, Pa.

Mr. S. H. Knight and Mr. E. J. Riner, formerly Contracting Engineer and Superintendent, respectively, of the Spokane office of the Northwest Bridge Works, have severed their connection with that company to engage in business for themselves under the name of Engineering Construction Co., with headquarters at Spokane, Wash. They will give particular attention to electric railways, irrigation works, bridges, foundations and reinforced concrete.

Col. Thomas W. Symons, Corps of Engineers, U. S. Army, retired, M. Am. Soc. C. E., who has been appointed Chief Engineer of the Civic Commission of Pittsburg, Pa., has begun work on the plans and specifications relating to the contemplated "hump" cut and other improvements in that city. Col. Symons is a member of the board of consulting engineers for the New York State Barge Canal and is Consulting Engineer on the new water system for Buffalo, N. Y.

Mr. William M. Torrance, M. Am. Soc. C. E., has been retained by Civil Engineer Frederic R. Harris, U. S. Navy, as an expert designer in charge of the designing work in connection with the new dry dock No. 4 in the New York Navy Yard, now under construction by the Holbrook, Cabot & Rollins Corporation. The design is being changed from massive concrete on piles to reinforced concrete on pneumatic caissons. Plans are now being considered also for deepening, lengthening and widening the dock.

Obituary.

Henry M. Steele, M. Am. Soc. C. E., formerly Chief Civil Engineer for J. G. White & Co., of New York City, died July 5, 1909, at his home in Asheville, N. C.

Albert M. Smith, Engineer of Distribution of the Consolidated Gas Co., of New York City, died in New York Feb. 27 at the age of 72 years. Mr. Smith was the son of Charles Smith, former General Superintendent of mains of the old Manhattan Gas Co., afterward absorbed by the Consolidated Gas Co., and himself began work in the engineering department of the company when he was 15 years old.

Amos E. Dolbear, Professor of physics, emeritus, at Tufts College, died Feb. 23 at his home in West Somerville, Mass. Professor Dolbear was born at Norwich, Conn., in 1837, and was a graduate of Ohio Wesleyan University in the class of 1866. He afterward studied at the University of Michigan and received from that school the degrees of A. M., M. E. and Ph.D. He was given the degree of LL. D. in 1902 by Tufts College, where he has been Professor of physics since 1874. It was in 1902 that he was obliged by ill health to retire from active work and was made a professor emeritus. Professor Dolbear devoted much of his time to scientific research and investigations and claimed to have been the originator of several inventions patented later by other men. Among his inventions were a writing telegraph, magneto telephone, static telephone, spring-balance ammeter and a wireless telegraph apparatus. He brought suit 30 years ago against Alexander Graham Bell over the use of permanent magnets in telephone receivers. This device was claimed by Professor Dolbear as his own invention, but his contention was not upheld by the courts. More recently he brought unsuccessful suit against Marconi in the attempt to restrain him from continuing his experiments in wireless telegraphy. Professor Dolbear was a Fellow of the American Association for the Advancement of Science and was the author of a number of books and papers along the line of chemistry and physics.

Engineering Societies.

COMING MEETINGS.

ILLINOIS WATER SUPPLY ASSOCIATION.
March 8-9. Annual meeting at University of Illinois, Champaign, Ill. Secy., Edward Bartow, Urbana, Ill.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 15-17. Annual convention at Chicago, Ill. Secy., E. H. Fritch, 962 Monadnock Block, Chicago, Ill.

AMERICAN WATER WORKS ASSOCIATION.
April 26-30. Annual convention at New Orleans, La. Secy., J. M. Diven, 14 George St., Charleston, S. C.

AMERICAN ELECTROCHEMICAL SOCIETY.
May 5-7. Annual meeting at Pittsburg, Pa. Secy., Jos. W. Richards, South Bethlehem, Pa.

APPALACHIAN ENGINEERING ASSOCIATION.
May 6-7. Annual meeting at Winston-Salem, N. C. Secy., Henry M. Payne, Morgantown, W. Va.

AIR BRAKE ASSOCIATION.
May 10. Annual meeting at Indianapolis, Ind. Secy., F. M. Nellis, 53 State St., Boston, Mass.

ENGINEERING SOCIETY OF WISCONSIN.—At the annual meeting, held in Milwaukee, Wis., Feb. 23 to 25, officers were elected as follows: President, C. V. Kerch, City Engineer of Janesville, Wis.; Vice-President, W. C. Lounsbury, Superior, Wis.; Secretary, W. G. Kirchoffer, Madison, Wis.

IOWA ENGINEERING SOCIETY.—The 22d annual meeting was held at Cedar Rapids, Iowa, Feb. 16 and 17, with about thirty members in attendance. Among the papers presented were the following: "Some Notes on Stucco Finish," B. J. Lambert; "Concrete Construction in Cold Weather," J. H. Chubb; "Rates for Electric Service," A. H. Ford; "The Direct Method in Illuminating Engineering," L. B. Spinney.

NEW ENGLAND WATER WORKS ASSOCIATION.—The March meeting will be held at the Hotel Brunswick, Copley Square, Boston, Mass., March 9. At the 2.30 o'clock session two papers will be presented, as follows: "Double Filtration of Polluted Waters," by H. W. Clark, Chemist, Massachusetts State Board of Health, Boston, Mass.; "Mediaeval Times of Germany," illustrated, by Desmond FitzGerald, Boston, Mass.

INTERNATIONAL CONGRESS OF INVENTORS.—The first annual convention will be held at Rochester, N. Y., June 13-18. The congress was established in 1906 and incorporated in 1907. It aims to unite the inventors of the world for the purpose of obtaining patent law reforms and protecting the interests of its members. An exhibition of patents and models will be held in connection with the convention which will include both recent inventions and some of those of particular interest patented during the early years of the U. S. Patent Office.

ENGINEERS' AND ARCHITECTS' ASSOCIATION OF SOUTHERN CALIFORNIA.—At the 17th annual meeting, held Feb. 9 at Los Angeles, Cal., officers for the ensuing year were elected as follows: President, A. F. Rosenheim; First Vice-President, Homer Hamlin; Second Vice-President, Frank Hudson; Directors, John Parkinson, T. D. Allin, S. R. Bivins and J. O. Marsh. The secretary is H. V. Osborne, Jr., city engineer's office, Los Angeles, Cal. At the dinner held in the evening after the meeting, Mr. James D. Schuyler, M. Am. Soc. C. E., read a paper on the Panama Canal.

LAKE MICHIGAN SANITARY COMMISSION.—This organization is composed of representatives of states and municipalities bordering on Lake Michigan, and its purpose is to prevent the pollution of the lake in the interests of the communities which draw from it their domestic water supplies. At the annual meeting, held in Chicago on Feb. 23 and 24, there were about 50 delegates representing four states and 30 cities. A report was presented regarding surveys that have been made to determine the extent of the pollution. The officers elected were as follows: President, Dr. Geo. W. Webster, Chicago; Vice-Presidents, Dr. G. A. Bading, Milwaukee, Wis., and Lawrence Becker, Hammond, Ind.; Secretary, W. R. Humphrey, Chicago.

AIR BRAKE ASSOCIATION.—At the 17th annual convention, to be held at Indianapolis, Ind., beginning May 10 and continuing for three or four days, committee reports will be submitted on the following subjects: Air Brake Instruction, Examination and Rating; Air Pump Piping, Fittings and Connections; Best Arrangement of Air Pump and Main Reservoir Capacity for 100-Car Train Service; Brake Cylinders and Connections and Recommendations for Overcoming Troubles Due to Cylinder Leakage; Inspection and Cleaning of Triple Valves and Brake Cylinders; The Past Year's Developments in Air Brakes; Questions and Answers on New York Brake Equipment; Questions and Answers on Westinghouse Equipment; Recommended Air Brake Practice.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.—A committee of publicity has been appointed which is made up of one member in each state. The function of this committee is to secure the publication of information and data pertaining to heating and ventilation, to cooperate with other organizations to improve living conditions, to furnish information regarding ventilation to boards of health or newspapers when desired, and in other ways which may appear later to educate the public to a realization of the benefits of proper air sanitation. The American Society of Heating and Ventilating Engineers has now about 350 members. This society exerted its influence in securing compulsory ventilation laws in at least five states and has caused the introduction of bills for compulsory ventilation in many more states.

The secretary is Mr. W. M. Mackay, P. O. Box 1818, New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—On Tuesday evening, March 8, a meeting will be held in cooperation with the American Institute of Electrical Engineers in the Engineering Societies' Bldg., New York City. A paper will be presented by H. G. Stott, M. Am. Soc. M. E., Superintendent of motive power of the Interborough Rapid Transit Co., New York City, and R. J. S. Pigott, on "Tests of a 15,000-KW. Steam Engine-Turbine Unit." The paper relates to the installation of low-pressure turbines at the 59th St. station of the Interborough Rapid Transit Co., and presents a discussion of this important development in steam engineering. The turbines operate on exhaust steam from the engines with which the station was originally equipped, and were added primarily to increase the output of the station. Three of them are now in process of installation. By the addition of the turbines, a total output of 15,000 KW. per combined unit, or nearly double the previous maximum output, is secured with an average improvement of 25% in the economy (between the limit of 7,000 KW. and 15,000 KW.) over the results obtained by the engine units alone.

The next monthly meeting of the society in Boston will be held March 11 in the auditorium of the Edison Electric Illuminating Co. The Boston Society of Civil Engineers and the Boston Section of the American Institute of Electrical Engineers will cooperate in the meeting. A paper will be presented on "The Training of Men as a Necessary Part of the Modern Factory System," by M. W. Alexander, M. Am. Soc. M. E. This paper was reprinted in Engineering News, Feb. 24, 1910.

At the spring meeting of the society at Atlantic City, N. J., May 31 to June 3, honorary membership will be conferred upon Rear-Admiral Geo. W. Melville, U. S. N., retired, Past-President of the society. This will occur at the Wednesday evening session, June 1.